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DIESEL RAILCARS

THE introduction and extension of Diesel traction in Britain and other countries is inevitably raising many practical problems. To any railway, a fundamental change of this kind upsets old traditions and, although senior railway officers give an enthusiastic lead, the rank and file of operating and maintenance staff impose a break on progress, even assuming their deep-rooted resistance to change is adroitly overcome. The publication by the Institution of Locomotive Engineers of a recent paper, "Experiences with Diesel Railcars," by Mr. M. J. Devereux, together with the discussions which took place on this paper at the Metropolitan and provincial meetings, provides a valuable symposium of collective experience in this field.

Mr. Devereux deals with experience of Diesel railcars and, incidentally, of Diesel locomotives, on the Irish State Railways (Coras Iompair Eireann). This system is going over almost entirely to Diesel power and has been putting railcars into service since 1952 and Diesel locomotives since 1948. The number of steam locomotives is being drastically reduced, from the 511 originally in use to 70.

The introduction of Diesel traction is based on four principles: (1) that all freight trains would be worked by Diesel locomotives; (2) that all regular shunting would be performed by Diesel locomotives; (3) that the spare availability of Diesel locomotives between the working of freight services would be used where possible for the working of passenger trains; (4) and that all passenger trains not worked by Diesel locomotives would be worked by Diesel railcars.

The difficulties of providing adequate servicing facilities for the railcars led to the decision to concentrate all maintenance and repair work at four principal depots only—Dublin, Cork, Limerick and Waterford. A Diesel locomotive can be serviced in a shed with only, say, one 60 ft. bay, whereas a Diesel railcar train of equivalent passenger capacity requires a shed 500 ft. long for its accommodation, if shunting is to be avoided. Furthermore, while fuelling of a locomotive can readily be carried out in the shed, railcars of the Irish Railways are fuelled in the open to avoid the smell of the fuel oil clinging to the passenger accommodation.

An additional advantage of restricting servicing to four main depots is that during the change-over period the natural centres of railcar operation are changed from time to time. Therefore the ideal is to build depots at which complete servicing of a train set can be carried out, including coach cleaning, watering of toilet tanks, filling buffet car tanks, gassing buffet cars, etc. The shed must be long enough to take a complete train set without having to separate some of the intermediate coaches, which might in certain circumstances prove very inconvenient, and involve a serious loss of time.

In order to build up an adequate maintenance staff it was found preferable to train a small number of competent fitters and electricians. Some of these men also received instruction at the works of the railcar manufacturers. The education of drivers who had previously been accustomed to steam locomotive working presented some unexpected difficulties. Mistakes such as various incorrect remedial actions in the event of breakdown, and their reluctance to change gear when they were losing speed on rising gradients, were thought to be due to the erroneous application of standard steam practice to Diesel traction.

The design of railcars involves many problems for which only experience can provide the answer. Mr. Devereux, for example, in referring to one particular design said that its outstanding feature was that it made use of many components from commercial road vehicles. Although this practice is economical in first cost it is considered by some to be inappropriate since railway service is generally more arduous than road service.

Railcar design, he said, fell into two categories: cars powered by engines of such a size that one axle could absorb all the torque without undue wheel slip, and those where the drive had to be spread among two or more axles because of the high torque of a larger engine. The choice between a small number of large engines and a large number of small engines is not easily decided, but certainly some of the earlier experiences on various railways of railcar operation showed that there was a tendency to under-power the railcars. Under such conditions the engines are required to operate beyond the range that would be considered reasonable in normal working.

Mr. Devereux said that the Diesel engines had proved to be about the most reliable part of the whole equipment on the cars, though when the forward and reverse dogs on one axle failed to operate correctly the one engine in question was driven backwards by the other three and thereby caused a serious failure. No major trouble had been experienced with fuel injection equipment, and since paper-element filters have been used, injector examinations have been extended to 20,000 mile intervals. Most of the failures with railcars have occurred in the transmission system.

The discussions following the presentation

of Mr. Devereux's paper revealed the widespread interest in Diesel operation, especially now that British Railways are committed to a big Diesel programme. The frank interchange of information and experience will be of great benefit, not least to the locomotive and railcar builders, who will undoubtedly turn it to good account in their drive to expand their export markets.

* * *

Plain Words

It is amusing to observe the desperation with which certain Americans are trying to destroy confidence in Britain's atomic energy achievements. Recently in Japan, Mr. W. Kenneth Davis of the United States Atomic Energy Commission, whose forecasts of nuclear power trends have been regarded by American businessmen as impartial guides to policy making, has assisted in a campaign to denigrate the Calder Hall type of reactor, which was described as cumbersome, expensive and inefficient. A member of the party is also reported to have said that Britain is in the " nuclear dark ages " compared with America. But in spite of these Machiavellian tactics, the Japanese seem unshaken in their resolve to buy a Calder Hall type of gas-cooled reactor, though it would be ironical if current ill-feeling in Japan over our hydrogen-bomb tests tipped the scales against us.

The Americans are offering pressurised-water reactors and other liquid-cooled designs, and indeed the Three Wise Men of Euratom have been sufficiently convinced by their arguments to include both gas-cooled and pressurised-water systems in their 15,000 MW (by 1967) programme. The American reactors require expensive enriched fuels, as distinct from the British models, which operate on natural uranium. It is significant that the United States are offering enriched uranium at a price roughly one-third the cost of enriching fuels in Europe. There can thus be little doubt that the sales pressure which is now being applied to Europe and Japan is aimed at extending their dependence on the United States.

The main American argument is that the capital cost of pressurised-water reactors is much lower than that of gas-cooled reactors. But over the 15 year depreciation period adopted by Euratom this advantage is balanced by the much higher fuel costs of the American design, even at United States fuel prices. In any case, the United States Joint Committee on Atomic Energy has reported an extraordinary rise in the capital cost of American nuclear power plants under construction, including the Shippingport pressurised-water reactor, the cost of which has risen from 37·5 to 55 million dols. Finally, the Americans have as yet no nuclear power station in operation. Britain has nearly a year's successful operating experience with a reactor which, unlike the American designs, does not suffer to any great extent from corrosion problems, and may lead to the highly efficient closed-cycle gas-turbine reactor system, regarded, even by the Americans, as very promising. It is significant that the Americans themselves have recently presented cost estimates for the two systems which strikingly favour the British design.

In a paper recently presented at the Fifth Atomic Energy in Industry Conference, in Philadelphia, Mr. Kenneth Davis and a co-author said: " This is a period of some discouragement with respect to the cost of building and operating power reactors. After the excessive optimism of two or three years ago, we are at grips with the hard realities of developing and building real nuclear power plants. This does not turn out to be an easy task. There are many difficulties, and the way ahead is not wholly clear." It appears that his confidence in America's performance is, in fact, not as high as he would have potential customers believe.

ENGINEERING CONSEQUENCES OF THE NEW DEFENCE POLICY

By Jules Menken

BRITAIN'S new defence policy as set out in this year's White Paper has the merits of clarity, restraint, and a good deal of realism. At its foundation lie changes in the technology of war which are summarised in the hydrogen bomb, the guided ballistic missile, and the nuclear submarine. The new policy will have important consequences for the engineering industries, as well as other and far-reaching implications of the greatest significance.

Three fundamental assumptions are central to the analysis and policy set forth in the White Paper. One is that there are " at present no means of providing adequate protection for the people of this country against the consequences of an attack with nuclear weapons." A second is that, in this age of weapons of mass destruction, " no country can any longer protect itself in isolation," so that " the defence of Britain is possible only as part of the collective defence of the free world." The third is that in these conditions " the overriding consideration in all military planning must be to prevent war rather than to prepare for it," and that, pending international agreement about disarmament, " the only existing safeguard against major aggression is the power to threaten retaliation with nuclear weapons."

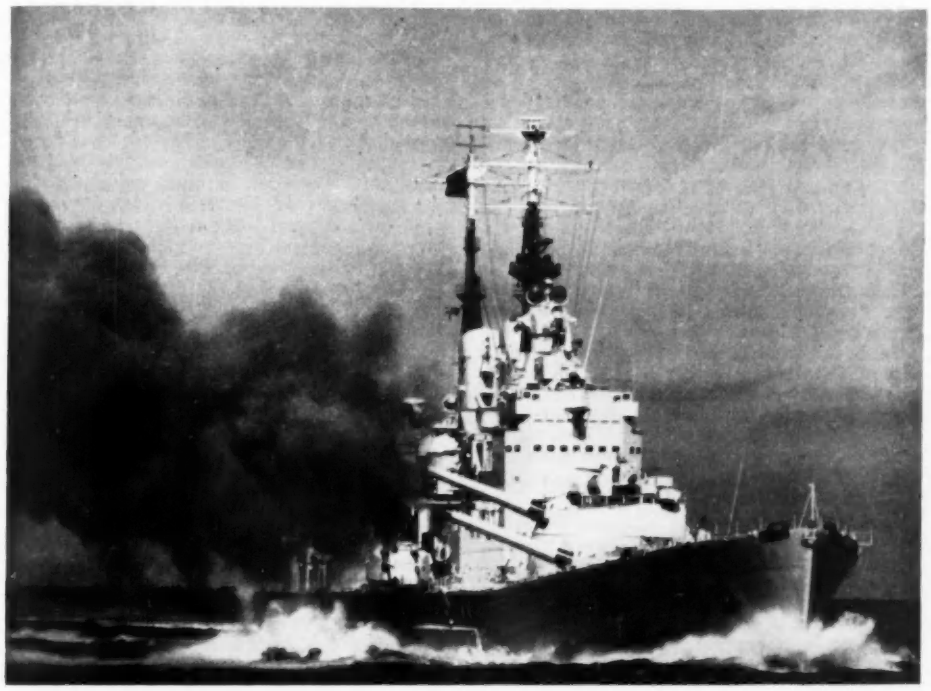
The Corporal surface-to-surface guided missile—significant of Britain's new defence policy.

From these and other assumptions the new defence policy arrives by appropriate steps at the tasks which Britain's armed forces must be capable of performing and goes on in the White Paper to indicate the shape and scale of the forces required to perform them. The main tasks are two. Britain's armed forces must be able " (i) to play their part with the forces of Allied countries in deterring and resisting aggression; (ii) to defend British colonies and protected territories against local attack, and undertake limited operations in overseas emergencies."

Within this general framework the first sector of Britain's armed forces comprises the deterrent forces and their defences. As is frankly acknowledged, the nuclear capacity of the United States provides the main force protecting the free world to-day. To this nuclear shield Britain proposes to make what the White Paper describes as " a modest contribution," comprising at present British atomic bombs and the " V " bomber force, and in future these components together with medium-range ballistic rockets (at first American, but later British) and British hydrogen weapons. These deterrent forces will be defended by a small manned fighter force progressively armed with air-to-air guided missiles and supplemented in the future by a ground-to-air guided-missile system which in time will replace a proportion of the manned fighter aircraft.

Nuclear air power by itself is not, however, a complete deterrent. The strategy of containment, though not referred to by name, is therefore to continue; which means, in the words of the White Paper, that " the frontiers of the free world, particularly in Europe, must be firmly defended on the ground." In the Middle East, Britain has obligations under the Baghdad Pact, while in the Arabian peninsula she must be ready at all times to defend Aden Colony and the Aden Protectorate, and also the territories on the Persian Gulf for the defence of which she is responsible. In South-East Asia, besides the defence of colonies and protectorates, and help in the external defence of Malaya, Britain has an international commitment as a member of the SEATO (South-East Asia Treaty Organisation) and ANZAM (Australia, New Zealand, and Malaya) defence systems to help preserve stability and resist the extension of Communism in that area. In addition, there are other and direct British commitments elsewhere; in Hong Kong and Singapore, in parts of Africa, and in yet other British colonies and protectorates.

The Defence White Paper envisages a variety of forces to meet these obligations and commitments. For the defence of Western Europe, one of the world's strategically vital areas, Britain will contribute ground and tactical air forces to NATO. For the defence of the Middle East, Britain will maintain land, air, and sea



Modern—but overtaken by technological change—the Navy's Vanguard

forces in that area and in East Africa. In the event of an emergency, whether caused by Communist aggression or otherwise, British forces in the Middle East would be made available to support the Baghdad Pact alliance, and would include bomber squadrons based on Cyprus and capable of delivering nuclear weapons. In South-East Asia it is proposed to maintain a mixed British-Gurkha force and certain air force elements, a substantial garrison in Hong Kong, a small naval force based on Singapore, and a Commonwealth Strategic Reserve, including a brigade to which Britain will contribute two battalions. British colonies and protectorates will also be garrisoned, though wherever practicable these garrisons will be considerably reduced. A Central Reserve will be maintained in the British Isles with a view to making possible the dispatch of reinforcements at short notice as a means, among other things, toward reducing the size of garrisons and other British forces overseas. This Central Reserve will be provided with a substantial fleet of transport aircraft.

The sea is the element which causes the greatest strategic perplexity. As the Defence White Paper says, " the role of naval forces in total war is somewhat uncertain." If there were a swift knock-out blow, naval operations would have no significance, whereas if the nuclear battle was not immediately decisive the defence of sea communications across the Atlantic against submarine attack would be most important, and perhaps vital. On the other hand, sea power still gives suitably equipped forces great value both in peace-time emergencies and in limited hostilities. Balancing these and other considerations, the Defence White Paper proposes a British naval and maritime air contribution to NATO, a navy based on a small number of carrier groups each composed of an aircraft carrier and supporting ships, maintenance of British naval strength east of Suez at about its present level, and the stationing as a normal practice of one carrier group in the Indian Ocean.

MEN AND MONEY

The combined strength of the three Services is now about 690,000. This figure includes uniformed United Kingdom adult males only. The corresponding total, including boys, apprentices, and women's services, is about 719,000.

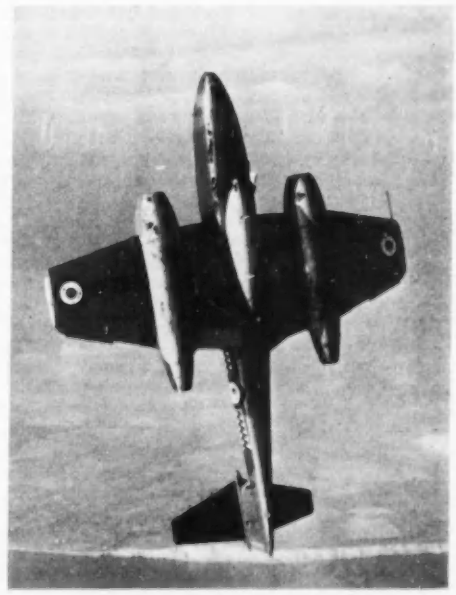
—the Army's Conqueror

During the twelve months to April, 1958, it is proposed to reduce the strength of 690,000 to about 625,000; while by the end of 1962, if present plans for ending National Service and improving recruiting are fulfilled, the Government aim at stabilising the armed forces on an all-regular footing at a combined strength of about 375,000, apart from Colonial troops and other forces recruited overseas, which now amount to about 60,000. Of the total of 375,000, the Minister of Defence has stated, the Royal Navy are expected to take about one-fifth, the Army a little more than two-fifths, and the Royal Air Force the remainder. In numbers such strengths would amount to about 75,000, about 160,000 and about 140,000, respectively. They compare with estimated active strengths at April 1, 1957, of 115,500 for the Royal Navy, 373,300 for the Army, and 230,000 for the R.A.F.

The planned reduction in manpower will not, however, imply a proportionate reduction in fighting strength. National Service involves an uneconomic use of manpower, especially in the training organisation, which in the three Armed Services now absorbs no fewer than 150,000 men who are training others or being trained themselves. If National Service could be abolished and regular recruitment substituted for it, substantial savings in manpower would be possible. Again, manpower savings are being sought over a wide field, and it is planned to extend the use of civilians instead of uniformed personnel wherever practicable. Apart from the weapons with which the forces will be armed, these changes, so far as they can be effected, mean that the planned reduction in fighting strength will be proportionately smaller than the planned cuts in total manpower. One further change of great importance will be the increasing number and proportion of technicians whom the Services will require, especially for guided-missile and electronic work.

An increase in the number of atomic weapons and the addition of hydrogen weapons and guided missiles, together with certain other changes, mean that the hitting power of Britain's future forces will be larger than to-day; indeed, if the increase is measured in the explosive equivalent of atomic and hydrogen weapons, it will be much larger. But it is also clear that the manpower reductions planned over the next five years, combined with the fact that reserve forces will be quite secondary in character and that no war-time expansion is contemplated (or, with nuclear warfare, may be possible), mean that the aggregate park of weapons and equipment in all three services will be considerably reduced. Just how the needed shrinkage will be phased in with new production of existing types and with the output of new weapons and equipment which are certain to be developed in future cannot now be foreseen. But the probability is high—it amounts almost to certainty—that the total of Government armament orders to industry will fall, and that their character and composition will change.

This conclusion is implicit, indeed, in the statement of the Defence White Paper that " it can safely be assumed that the new plan, when it is fully implemented, will further appreciably reduce the burden on the economy. Even so, because of what the White Paper calls " the ever-increasing complication of modern weapons and



—the R.A.F.'s Meteor.

equipment," the fall in the level of defence expenditure as a whole is not expected to " show a decline in any way comparable with that in the manpower strengths of the forces."

The intricacies of official accounting, among other reasons, make it difficult to indicate both briefly and accurately within what limits the new defence policy will probably affect the engineering industries as a whole. Perhaps the best short measure is the budgetted *net* defence expenditure on production and research, including, however, receipts by industry from United States defence and other aid. " Net " in this context means without what are called appropriations-in-aid, which include financial transactions between Government departments, sales of surplus material, and other items, largely of a financial or accounting character. These net figures for the past five years are shown in the table below; the corresponding gross figures—i.e., including appropriations-in-aid—have in the last two financial years been about £100 million larger for the three Service Departments together and, for the Ministry of Supply, £80 million larger in 1956-57 and £38 million larger in 1957-58.

United Kingdom Budgetted Net Defence Expenditure on Production and Research

(Including expenditure out of United States Aid Funds)
(In £ million)

Financial year.	By Navy, Army, and Air Force.	By Ministry of Supply.	Total.
1953-54 ..	668	77	745
1954-55 ..	645	103	748
1955-56 ..	560	104	664
1956-57 ..	479	133	612
1957-58 ..	401	147	548

As this table indicates, budgetted net expenditure on production and research by the Navy, the Army, and the Air Force has fallen over the past five years by about 40 per cent. Ministry of Supply outlays of the same character, on the other hand, have increased by over 90 per cent.—largely, no doubt, as a result of the development and production of atomic weapons, together with work on hydrogen weapons and on guided missiles—with the result that total production and research expenditure has fallen by about 26 per cent.

The forces pulling in various directions make it impossible to forecast future expenditure of this character, while further uncertainty is added by the inflation factor. On the most commonsense grounds, however, it would seem unlikely that *net* production and research expenditure by all departments will be reduced by the new defence policy below perhaps £400 to £450 million annually. Allowing for the fact that defence orders reaching the engineering industries are made out of *gross* and not out of *net* expenditure by the Service departments and the Ministry of Supply, it may be hazarded as a guess that in future such orders may continue to total perhaps £350 to £450 million. These figures have no official basis and represent the roughest of rough appraisals; but on the published facts they may perhaps not be too far out as regards general scale.

NUCLEAR WEAPONS

The Defence White Paper states that " British atomic bombs are already in steady production and the Royal Air Force holds a substantial number of them." What the White Paper calls " a British megaton weapon "—it is presumably a bomb, though this is not expressly stated—has also been developed and is being tested; " thereafter," the White Paper says, " a stock will be manufactured." The White Paper states that high priority will continue to be given to the development of British nuclear weapons suitable for delivery by manned bombers and by ballistic rockets. Nuclear warheads are also being evolved for defensive guided missiles; these are presumably surface-to-air missiles. There is no statement that nuclear warheads of British design are being developed for the Corporal surface-to-surface missile bought from the United States with which the British Army is being equipped, though in the House of Commons on May 14 the Secretary for War described the Corporal as " our long-range tactical nuclear guided weapon "; he added that development of a shorter-range nuclear guided weapon is being begun.

Increased emphasis, the White Paper states, will be placed on the development of nuclear propulsion for maritime purposes because of its civilian as well as its naval importance. In this task the Admiralty are making progress with the design of the nuclear submarine Dreadnought and its power unit, while experimental work under the Atomic Energy Authority, including work on problems of shielding from radiation, has begun.

So strict is security about all matters connected with nuclear weapons that it is impossible to estimate what is the total outlay on them, or how much of this will accrue to the engineering industries in one form or another. The available evidence, however, suggests that the latter sum is to be measured in tens—or at most in scores—of millions.

GUIDED MISSILES

The further development and increasing use of guided missiles for air defence, ground attack, and intermediate or long-range deterrent purposes are among the prospects clearly envisaged in the new defence policy. Particulars of the latest developments, so far as these have been announced, are as follows:—

The Fairey Fireflash, a beam-riding weapon and the R.A.F.'s first air-to-air guided missile, is about to begin full-scale service trials, the purpose of which is to establish tactical doctrine and the operational characteristics of such weapons. During acceptance trials several target aircraft were shot down at operational ranges even by Fireflash weapons which were not fitted with explosive warheads.

A more advanced air-to-air missile for the Royal Air Force is the de Havilland Firestreak, which uses infra-red homing. This missile will shortly begin its acceptance trials, and in due course will be fitted to Javelins and P.1's. An American infra-red homing missile, the Sidewinder, is reported after official demonstration to be about 9 ft. long and 4½ in. in diameter, and to have a speed of about Mach 2·5 and a range at high altitude which approaches 30 miles The overall length of the Firestreak is reported to be some 12 ft.; a published photograph (ENGINEERING, May 10), suggests that its diameter is considerably larger than 4½ in.; the body volume and weight must therefore be a good deal larger than those of Sidewinder, which implies that both range and lethality must be greater.

The first R.A.F. ground-to-air missile station is now under construction in Lincolnshire, and will be brought into use for service trials in 1958. The missile used will be the Bristol-Ferranti Bloodhound, a semi-active homing type. A statement by the Bristol company says that the system could differentiate between one aircraft and two flying in close formation, and would thus permit each to be attacked separately.

A limited production order has also been placed for another ground-to-air guided-weapons system developed by English Electric Company, Limited. This weapon, called the Thunderbird, was originally designed to use a Napier liquid-propellant sustainer motor, but there is now an alternative version of equal performance which uses a solid-fuel motor. Thunderbird is said to have an overall performance better than that of the U.S. Army's Nike-Ajax, and generally of the same order as that of the later Nike-Hercules.

For the Navy, orders have been placed for four of the new design of Fleet Escorts with guided weapons. These vessels will be the first that will be armed with the guided missile called the Sea Slug, a surface-to-air weapon developed by Sir W. G. Armstrong Whitworth Aircraft Limited. It is presumably this missile that has been tested in the Girdleness, the Navy's experimental guided weapons ship which was commissioned in July, 1956, and in September successfully fired her first test missiles in a series of satisfactory firings.

For the Army, American Corporal surface-to-surface guided weapons with a range believed to be of the order of some 50 miles have been procured. On May 14 the Secretary for War stated that an anti-tank guided weapon is under development. The first guided weapon regiment armed with Corporals is being raised, and a second regiment will be raised during the course of the financial year. The Army now has three guided weapons training wings, one at the School of Artillery, another at the School of Anti-Aircraft, and a third at the R.E.M.E. Training Centre.

A powered air-to-ground guided missile—or " stand-off bomb " —is under development. This missile will enable the V-bomber force to launch nuclear and thermonuclear weapons at a considerable distance from their targets, and will correspondingly increase their deterrent power.

While the V-bomber force thus armed will provide " for many years " the foundation of our deterrent power (*Memorandum on the Air Estimates*. Cmnd. 149, par. 14), the Defence White Paper states that it is intended that the V-bomber force should be supplemented by ballistic rockets, and that agreement in principle was recently reached with the United States for the supply of some medium-range missiles of this type. This agreement, however, does not mean that a British intermediate-range ballistic missile will not be developed, and in fact it is intended that this should be done. Close co-operation with the United States over research on guided missiles and ballistic rockets was begun in 1953, has benefitted both countries, and will be maintained and further developed.

AIRCRAFT

While the new defence policy involves smaller numbers of aircraft and changes in types, work on the development of a supersonic manned bomber and on fighter aircraft of types more advanced than the supersonic P.1 will stop. Although the new types will in many or all cases be more costly than those they replace, the financial outcome for industry cannot easily be forecast, but it is practically certain to mean less expenditure.

In Bomber Command the medium-bomber force is building up steadily. Valiants are already at full strength, but the number of Vulcans will increase steadily, and the Victor will enter service during the year. The Canberra light-bomber force will be about halved, though the reduction will be much more than counterbalanced by the nuclear capacity of the remaining Canberra squadrons.

The new defence policy changes the role of Fighter Command, which will no longer try to provide protection for the country as a whole, but will confine itself to defending the bomber bases from which the nuclear deterrent will be launched if need be. This task the Defence White Paper describes as " feasible." The fighter force required for this limited purpose will be smaller than the present fighter force. It will be progressively equipped with air-to-air guided missiles. Day-fighter squadrons are being equipped with the latest mark of Hawker Hunter, the F.6. A production order has been placed for the English Electric supersonic P.1. The Gloster Javelin is well established in Fighter Command, and is officially stated to be well liked by the air crews.

By the end of March, 1958, the present number of aircraft in the Second Tactical Air Force in Germany will be approximately halved. The reduction will mainly affect the day-fighter/ground-attack element of the Command; and in order to offset it by higher quality the remaining squadrons will be re-equipped with Hunter 6's.

In Coastal Command the long-range maritime reconnaissance force is now wholly equipped with Avro Shackletons, a new version of which (the Shackleton III) will soon enter service.

Canberras and Hunters are being introduced into the Far East Air Force, which in due course will also receive Scottish Aviation Twin Pioneers.

For Transport Command, whose primary role continues to be the provision of strategic and tactical mobility for all the Services, 13 Bristol Britannias are on order, two squadrons of Blackburn Beverley freighters are in being and a third will form shortly, while a squadron of de Havilland Comet II's is the first pure-jet transport squadron in any air force.

Bristol Sycamore and Westland Whirlwind helicopters continue to give good service. The Bristol 192 twin-engined helicopter is on order for the R.A.F. In the R.A.F. initial flying training is now based on jet aircraft, and a substantial order for Hunting Percival jet Provosts is being placed.

In the Royal Navy the first deliveries of the Supermarine N.113, a twin-engined day-fighter which will be known as the Scimitar, are expected during the financial year 1957-58. The new de Havilland D.H.110, a two-seat all-weather twin-jet fighter which will be known as Sea Vixen, is coming along well and its production programme is up to date. Its armament includes air-to-air guided weapons, which have already been fired under test conditions. A new naval strike aircraft, the N.A.39, is under development. Its range will be considerable, it will be able to carry an atomic bomb, and when in service it will make what is officially described as " a most formidable addition to the striking power of the Royal Navy." During the second half of 1957 the Navy will also be receiving considerable numbers of Westland Whirlwind helicopters for use in an anti-submarine role; these machines can also carry troops.

ELECTRONIC EQUIPMENT

Current developments obviously increase the importance of, and in due course will probably increase expenditure on, electronic equipment of one kind or another. The control and reporting system of the Royal Air Force is being planned in relation to the requirements of guided missiles and, in due course, to defence against ballistic missiles. The R.A.F.'s new radars have a very high performance, which is being exploited to the full and is making it possible to reduce the number of stations in the control and reporting organisation. On the other hand, all guided missiles have electronic equipment of some kind as part of their computer and control mechanism. Complex electronic gear is also required for high-level bombing, for all-weather fighters for naval combat vessels, for anti-submarine work, and for important types of modern signals and communications equipment. With smaller forces the need for accurate information and close control is likely to increase rather than diminish; and if developments in other fields are paralleled, any saving on quantity is likely to be more than made up by larger outlays on more complex devices and equipment of higher quality.

NAVAL SHIPBUILDING

The current naval estimates for shipbuilding, repairs, maintenance, etc., and for naval armaments total about £156 million net, a reduction of about £26 million or roughly 14½ per cent. as compared with 1956-57. The cuts fall mainly on purchases of material and on contract work —i.e., on building, etc., done for the Royal Navy by industry.

Modernisation of aircraft carriers continues, as does construction of the carrier Hermes. An ominous note is struck in the *Explanatory Statement on the Navy Estimates* by the First Lord of the Admiralty (Cmnd. 151) when, after describing the modernisation of the Victorious—which will be the first British carrier in service with a fully angled deck, and which will also have steam catapults, new radar and landing control systems, the latest arrester gear, and the equipment and facilities required to arm aircraft with air-to-air guided weapons—and after saying that the forthcoming modernisation programme of the Eagle is planned to bring her up to the same standard as the Victorious, the text continues: " Various considerations—above all, the financial limitation—make it impossible to aim at so high a standard in the case of all our operational carriers."

Among other ships, the construction of Tiger class cruisers continues, with the Tiger herself expected to join the Fleet in 1959. This class is to replace existing cruisers in the active fleet. The new design of Fleet Escorts will be larger than the present conventional types, and will have a very powerful armament and a considerable endurance. During 1957-58 12 more frigates should complete. Among submarines, the Excalibur, a second experimental high-speed vessel using high-test peroxide, should complete in 1957, while some fast battery-driven submarines of the Porpoise class are under construction. The minesweeper building programme is almost completed. Modernisation of existing maintenance ships is being taken in hand with a view to increasing the ability of the Fleet to operate independently of highly organised shore bases—an important precaution against the hazards of nuclear warfare.

ARMY EQUIPMENT

The Secretary of State for War's *Memorandum on the Army Estimates* (Cmnd. 150) states bluntly that " orders for new equipment will be reduced." The *Army Estimates* show that gross estimates for Warlike Stores—i.e., guns and small arms, ammunition, mechanical transport (wheeled and tracked) and light aircraft, signals and wireless equipment, and miscellaneous warlike stores—will be reduced from about £102 million in 1956-57 to about £64 million this year.

The Secretary for War's *Memorandum* says that the Army aims to simplify its equipment as much as possible, that it plans to produce a family of weapons with no supplementary or overlapping members, and that development projects which offer only marginal improvement have been discarded. Among details which may be mentioned, further progress has been made in equipping the Army with operational radiac instruments to measure nuclear radiations; troop trials of the FN rifle have fully justified expectations, over 14,000 of these rifles are now in service, and United Kingdom production is due to start this year; a number of Bren light machine guns have been converted to fire the NATO 7·62 mm. round and are now in service; large-scale production of a new sub-machine gun to replace the existing Sten gun is planned for 1957-58; user trials of possible replacements for the Vickers machine-gun will take place this year; and re-equipment with new-type radio sets, which began last year, will continue.

On May 14 both the Secretary for War and the Under-Secretary for War gave the House of Commons certain further details. Britain will produce 4,000 FN rifles this year and 36,000 next year, and the whole Army will be supplied with them by 1961-62. A new medium tank is in an advanced state of development. The 25 pounder gun still has some years of efficient service ahead of it, but in due course will be replaced by a new field gun. To deal with low-flying aircraft the old Bofors 40 mm. gun is being replaced by a new light anti-aircraft gun, the L70, which has improved radar fire-control that is stated to give the weapon a very high performance.

DEFENCE'S URGENT NEEDS

Even with the smaller programme envisaged under the new defence policy, it is clear that defence will continue to make heavy demands upon industry and upon the scientific and technological ability of the country. No doubt should exist about the urgency and necessity of these demands. In the past, time and geography tipped the scales in Britain's favour against foreign threats. To-day geography is still helpful—much more so than many people realise—but time is against us. In the past we could complete our preparations after war had begun; to do so was risky, but it was possible. To-day only strength in being can prevent war—or can promise survival to some of those who may have war thrust upon them.

Weekly Survey

Cover Picture: *The cover picture shows a pit-type gas carburising furnace retort during manufacture. In all types of gas carburising equipment a thoroughly sealed furnace chamber is essential to satisfactory operation. In furnaces with work spaces up to* 36 *in. in diameter this requirement is most readily met by the use of a heat-resisting alloy retort or muffle, in which the charge is contained, and into which the carburising atmosphere is fed. With this construction, heating—external to the retort—may be either by exposed electric resistors of the conventional pattern or by open gas burners.*

* * *

Is Exporting a Virtue?

Speaking last week at the annual meeting of the Institute of Export, the President gave a fighting speech on the need to export. He emphasised the necessity to stir the apathy of manufacturers in their attitude to exports. Like many a good cause his arguments suffered to some extent from a surfeit of zeal. It is true that it is vital to export and that this country will suffer all the pains of a falling standard of living if it does not do so to an increasing extent. It is dangerous, however, to suggest that exporting is a national obligation, that those who export should be given some public recognition for it, or that the more obdurate minority should lose their raw materials. To accept the implications of such a policy would involve the control of raw materials and the passing of public judgment on private individuals in a large number of cases where there would be neither the time, the staff nor the opportunity to refute allegations.

The engineering industry above all others is aware that exporting is not a question of exhortation on the one hand or moral responsibility on the other, although these are useful elements to be used with circumspection in generating enthusiasm. He who exports for the first time is laying himself open to development of a new piece of organisational machinery, to the most exasperating reactions to tenders and competitive prices and to the maintaining of standards of workmanship which only close production control and the development of new ideas for products can sustain. It is a race for able and enterprising managements in which size has often an advantage. Under such conditions few concerns are public spirited enough to export without prospect of reasonable profits on the one hand or full utilisation of their capacity and consequent reduction in overheads per unit of output on the other.

It is necessary to provoke controversy on exports and the Institute of Export is to be congratulated for doing so. If exhortation becomes too vehement, however, there is a danger of the producer who is comfortably established with adequate profit margins in the home market saying in the words of Sir Toby Belch " Because thou art virtuous doest thou think that there shall be no more cakes and ale? "

* * *

Export Markets in South America

Venezuela and the Argentine Republic are the two most important markets for British exports in South America, the value of total British exports to the former in 1956 being £33·3 million and to the latter £17·3 million. Many British exporters have, however, been discouraged from actively promoting exports to South America by the difficulties of securing payment. The chairman of the Bank of London and South America Limited recently expressed the opinion that in the not too distant future the South American market may well prove of far greater

importance than the more traditional markets, particularly in view of recent events in the Middle East. He went on to say that if British exports are not to be ousted from South America it will be necessary to draw on a far larger source of lendable funds since the demand is mainly for manufactured capital goods and for large-scale development programmes for which the importing countries are likely to be able to pay only over a period of years.

Payment difficulties do not in fact apply to to any very great extent to Venezuela owing to the higher level of prosperity there based on the rapid expansion of oil and iron ore. This is reflected in the fact that British exports to Venezuela rose from £24 million in 1955 to £33·3 million in 1956 and are expected to rise still further in the near future. Important contracts secured by British companies include equipment for oil companies, a television station and electricity generating plant while exports of road vehicles and aircraft were valued at £4·6 million in 1956.

By contrast, exports to the Argentine fell from £23·5 million in 1955 to £17·3 million last year, in spite of the fact that British imports from the Argentine rose from £86·7 million to £92·6 million. To some extent economic prospects are blighted by the influence of economic nationalism, one example of which is that while the Argentine is dependent on imports for over half her total fuel requirements, she will not allow foreign companies to develop her oilfields. There is, however, a large potential market for electrical machinery, transport equipment and other capital goods, and it will be unfortunate if this market is lost to foreign competitors through neglect by British manufacturers or the inability of the United Kingdom to arrange the necessary credit.

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Extravagance with Coal

The need for putting indigenous fuel supplies to their best use is a well worn theme. Even with the greatly expanded nuclear programme, the major part of United Kingdom energy requirements will have to be met by coal, and a substantial margin by oil. This need for conservation was stressed at the annual general meeting of the Institution of Gas Engineers last week. In a paper on coal supplies for the gas industry, Mr. Charles Johnson of the Gas Council, while drawing attention to the difficulty of estimating the requirement of conventional fuels during the transition period of nuclear power, stressed the scope for economy in coal utilisation. In 1955, coal accounted for over 85 per cent. of the fuel used in Great Britain. Nearly half the total usage of fuel occurred as coal burned in the raw state, accompanied by ash, smoke, and waste; gas and coke on the other hand were equivalent to only half as much as coal burned in the raw state.

Fuel economy as a means of defending the balance of payments by minimising oil imports is only one aspect of the question. The other is the inevitable increase in the requirement of smokeless fuel as a result of the Clean Air Act of 1956. In spite of competition in some areas from electricity, which appears, according to the Institution's President, Sir Henry Jones, not to be based on commercial considerations so much as a desire to eliminate gas, both domestic and industrial demands for gas are likely to continue to expand. Recently, however, the gas industry has inclined to sources other than coal for some part of its raw material, so that there has not been a corresponding production of coke. Adequate supplies of suitable coal will in future be of great importance.

Two main conclusions were reached by Mr. Johnson. The first is the need for study of the best way of producing gas and coke and of the use of underground storage of gas in suitable geological formations, as practised in America. The second is the need for discovering new means of diverting coal from wasteful usage in the raw state to more economical outlets. There has been an understandable preference for using price to govern this process rather than restrictive legislation. Unfortunately, this has not had the desired effect of diverting consumers to the use of general-purpose coal or making them conscious of the need to economise in fuel consumption, while at the same time it has raised the prices of gas and coke. The English tradition of sending large quantities of smoke and heat up the chimney dies hard. The Scottish tradition, enshrined in the remark, " Lang may your lum reek," seems to be even more firmly established. Whether prices are high or low (*pace* the new Clean Air Act) the smoke goes up the chimney just the same.

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Steel for Oil

The Prime Minister announced last week that the Government have plans to reduce the country's dependence on the Suez Canal. He has appointed Sir Matthew Slattery, chairman and managing director of Short Brothers and Harland, as his special adviser on transport facilities for oil. Under the personal direction of Mr. Macmillan, Sir Matthew will see to it that the oil companies have all the steel they need to build large " round-the-Cape " tankers, additional pipelines and increased storage capacities. The large supplies of steel plate required to carry out such a programme will be hard to find, and a shortage is inevitable between now and 1962, as forecast in our article " Steel Plate: The Threat of Scarcity," published on April 12 (page 457). Plans now under way should increase plate capacity by some 60 per cent. over the next five years, but Sir Matthew Slattery may well be forced to conclude—when shipbuilding's other needs, and those of other industries are taken into account—that the industry's plans are inadequate. To press forward the oil transportation plans with the " real sense of urgency " the Prime Minister mentioned, either supplies will have to be allocated in accordance with priorities or imports considerably increased. A major problem facing the iron and steel industry is that of securing the increased tonnages of raw materials required. The overall development plans of the industry provide for an increase in steel capacity to 24 million tons in 1957 and 28 million tons by 1962, at a capital cost of £575 million. A further 30 per cent. expansion in crude steel output is planned over the following five years.

In 1956 the output of pig iron rose by about 700,000 tons, but substantially the whole of this increase was derived from foreign ores, of which imports reached the record level of 14·3 million tons. For the bulk of the future expansion in the output of pig iron the industry must look of the political disturbances throughout the whole of North Africa, British Iron and Steel Corporation (Ore) Limited, which boys in bulk for the whole of the industry, has negotiated long-term contracts for further supplies from Venezuela, Brazil, Newfoundland and Liberia. This will inevitably create a heavy demand for ore-carrying ships, and by the early 1960's the Corporation hopes to have available a fleet capable of transporting some 10 million tons a year. This is still only about half the tonnage required and will leave a substantial demand for tramp tonnage. It is clear therefore that a necessary concomitant of any large increase in the building of supertankers is a high level of output of ore-carrying ships.

The answer Mr. Macmillan is seeking may well have been given before he spoke in the House at the annual conference of the Chartered Institute of Secretaries in Cardiff by the managing director of the Steel Company of Wales, Mr. E. Julian Pode. The main conclusion of his paper, entitled " Steel in 1957 with Particular Reference to South Wales," was that " there is room for considerable expansion in the steel industry in the shape of a fully integrated iron and steel works." That Mr. Pode should want this works at Newport is incidental. The statement's importance lies in its confident advocacy of expansion.

The relationship of Sir Matthew Slattery and Lord Mills remains to be explained. In respect of steel capacity and also in the lead given to the oil companies concerning the setting up of new " super-tanker " discharging facilities, the Prime Minister appears to have taken over from his most recently appointed senior minister.

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Too Much Petrol?

The immediate reduction of petrol prices following de-rationing could be the result of the re-opening of the Suez Canal to British tankers. The emergency surcharge of 1¼*d.* a gallon was removed and dealers' margins cut by ¼*d.* in all oil products. Few expect prices to return to their pre-Suez level, though petrol may yet become cheaper in order to stimulate consumption. There is a tendency to over-production in most of the world's refineries, since a high level of demand for middle distillates—such as Diesel oil—has developed in the past two or three years in excess of the industry's own estimates. There is some flexibility in the plants, but not enough for a continued increase in the demand for gas and Diesel oils in relation to the demand for petrol. Refinery stocks of petrol are very high, and further price reductions—even if temporary—may well be forced upon the industry.

The prospect of abundant and cheaper petrol is likely to complicate the task of a good many people. Traffic congestion in London and other large towns has grown steadily over the past three weeks. Sir John Elliott, chairman of London Transport, spoke last week of new methods to keep the buses running to time: " London Transport have used the rationing period to introduce new and greatly improved methods of bus control and supervision in readiness for this very day, and we have further tricks up our sleeve to help us to offset the effect of street congestion which is quite serious once again." The tricks up Sir John's sleeve to keep the streets free of parked cars and vans will have to be almost magical in their effect if this major problem is to be solved quickly.

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Planning in Industry

" Too often, heads of firms rely on hunch, with quite inadequate information available. Too often proposals for sales are not thoroughly analysed, nor are their demands on production capacity fully discussed. Hunch and drive have their place but they alone are not enough to run a Twentieth Century business successfully." This was said by Lord Piercy, chairman of the Industrial and Commercial Finance Corporation at the opening of the Institute of Directors' one-day course on industrial organisation and forward planning.

Lord Piercy spoke from experience. The I.C.F.C. are all the time facing the difficult problem of deciding whether or not to support small or medium businesses which want to expand, develop a new product or extend a market, but which have not really thought out in sufficient detail what is involved. The shortage of capital in British industry has rarely been greater, particularly among small and medium companies that remain in private hands. Bank finance, or uneconomic and unsuitable City finance, are the only sources available if the time has not yet come to seek authority " to go public " from the Capital Issues Committee, or if the C.I.C. have refused to grant it. Yet I.C.F.C. face a shortage of acceptable applicants, very often for the reasons given by Lord Piercy of inadequate planning and confused thinking.

The engineering industry includes thousands of companies needing capital, and among them

only a fraction would be in a position to satisfy an investor's most justifiable requests. These companies account for a large proportion of the national income, and are unable to expand without running the risk of going bankrupt. Unless they can expand, their assets tend to atrophy and go to waste. The need for better planning is therefore more pressing now than at any time during the inter-war period.

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Prizes for Accounts

The annual awards made by the *Accountant* for the two best company reports and accounts were won this year by the United Steel Companies, Limited, and Trawlers Grimsby Limited. In both cases the reports were for the year ending September 30, 1956. They are both clearly designed to provide facts and figures—not only about the company's financial results but about their activities, their products, their equipment, etc.—for large numbers of people. Clarity, conciseness and informative, striking, illustrations are common to both, although United Steel went much further in the use of colour illustrations than Trawlers Grimsby. The latter concentrated on telling a stimulating story—of deep-sea fishing and food processing—simply, fully and in a form very easy to read.

United Steel won the award at their first attempt in preparing accounts containing a maximum of information on the company's background and performance. Their secretary, Mr. R. Peddie, who was largely responsible for the innovation, explained that he had attempted to produce all salient and significant figures in the accounts " in the hope that their meaning will become clearer to those with little knowledge of accounting." In this respect, Trawlers Grimsby are also outstanding. Their report can be read in a few minutes and a clear conception remains of what they do, how they did it last year and how profitably.

The development of the easy-to-read, informative, company report is a feature of post-war Britain. An increasing number of companies find the trouble and expense of producing a first-class document a good investment in public relations. The investor needs to be tempted, for competition for capital increases rather than diminishes; the operatives and staff need to be taken into the management's confidence; the customers and suppliers also have become a target of this, one of the newest and perhaps the most constructive, forms of publicity.

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Cloudy Skies for Aircraft?

The aircraft industry has had a good and active year in 1956. With the publication last week of the report and accounts of Vickers Limited and Bristol Aeroplane Company, Limited, most of the leaders in the industry have told their story. The shocks came in the last few weeks. First there was the Government's decision to cut heavily all orthodox defence orders. For many companies—English Electric and Bristol Aeroplane being prominent exceptions—this will mean a severe reduction in military work beginning to be felt in 1958. The second shock was even more unpleasant, as it affects orders for civilian aircraft and, more particularly, suggests that the future may not be quite so good as had been supposed. This was the announcement by Capital Airlines in the United States that orders placed for 14 Comets and 15 Viscounts would be deferred. The reason given was that operating profit margins were too small to sustain a continued high level of investment.

Perhaps too much importance is being attached to Capital Airlines' action. Most airlines have been complaining of reduced profits of late, but the remedy is largely in their own hands. It seems inconceivable that demand for fast air transport should fall and thus discontinue a sharply rising trend. Recent figures published by Vickers indicate that orders for the Viscount (at the end of 1956) were worth £125 million ; The figures recently published in the U.S. by Lockheed tell a similar story. Deliveries of commercial airliners in 1956 totalled £72 million (£45 million in 1955); the value of orders was £165 million. In Bristol's case the orders for the Britannia continue to support the company's confidence in this aircraft. It has become clear that the propeller-turbine aircraft is a most effective profit earner: Capital Airlines made a profit on their 60 Viscounts and a loss on their piston-engined aircraft.

The industry's prospects were well summed up by Sir Reginald Verdon Smith, chairman of Bristol: " Looking ahead, it is evident that the number of new aircraft projects undertaken in this country will be fewer, the competition to secure them will be keener, and the proportion of business related to civil and military transport, as distinct from combat types, will be greater than in the past." For these reasons, the well diversified company will tend to be happier than the pure aircraft constructor. Yet the future, for a company able to produce aircraft with high load factors and low operating costs, should be anything but cloudy.

Letters to the Editor

MEASURING EYE MOVEMENT

SIR, I have read with interest your article on " Measuring Eye Movement " (ENGINEERING, April 19, page 492). The only part of the article which puzzled me a little was the reference, in the third column, to the application of the method.

The article is mainly—if not entirely—concerned with voluntary eye movements, and the physiological mechanism involved in overshoot and undershoot. This is an inherent property and physiologically, in my opinion, linked up with the fine scanning movements which go to make up what is somewhat anomalously called fixation. It is difficult for me to see how this could be exploited by an industrial psychologist. Again, the link-up with the parts of an advertisement which attract the eye first is very difficult to follow. There are half-a-dozen subjects mentioned in this paragraph, all extremely interesting, possibly connected, but by no means so simply linked up as is rather hinted at in the article.

Records on interesting research into the method have been made by P. Dieterle and G. P. von Berger (*Riv. Oto-neuro-oftal*, vol. 29, page 1, 1954); G. Mackensen and S. Harder (*v. Graefes Arch. Ophthal.*, vol. 155, page 397, 1954), and others.

Yours faithfully,
Frank W. LAW,
M.D. F.R.C.S.

36, Devonshire-place,
London, W.1.
May 14, 1957.

★ ★ ★

SIR, I much appreciate your allowing me to see Mr. Frank W. Law's letter about your article on our eye movement measuring apparatus. I have read his letter with much interest and I am grateful to him for the references, with neither of which I am familiar.

The undershoot or overshoot which often occurs, when changing from one fixation point to another through a fairly large eyeball rotation angle, takes the form of a brief fixation followed by a final small saccadic movement which " homes " the eyeball on to the " target " fixation point. The extent of undershoot or overshoot may be as much as 10 per cent. of the distance between the starting and the aimed-for fixation point, i.e., up to 3 degrees or more of eyeball rotation. As far as I am aware, the intra-fixational eye movements (F. Ratcliff and L. A. Riggs, " Involuntary Motions of the Eye During Monocular Fixation," *J. Exp. Psychol.*, 1950, vol. 40, page 687; R. W. Ditchburn, " Eye Movements and Visual Perception," *Research*, 1956, vol. 9, page 466) have never been reported to be larger than 1 degree of the arc. It seems more likely that this eyeball undershoot or overshoot is similar to the secondary adjustment, following the primary movement, which the hand often makes in a simple acquisition tracking task (L. V. Searle and F. V. Taylor, " Studies of Tracking Behaviour—I. Rate and Time Characteristics of Simple Corrective Movements," *J. Exp. Psychol.*, 1948, vol. 38, page 615). Whether there are significant differences between people in eyeball undershoot or overshoot, and whether such differences, if existent, correlate with differences in task, training or skill of the persons concerned, remains to be seen. I hope soon to conduct experiments which may perhaps throw some light on these matters.

This technique of electro-oculography can be used to study successive eye fixations, in the same way that other eye movement recording techniques have been used. A direct cinéphotographic method has been used by several workers (see, for example, J. S. Karslake, " The Purdue Eye-Camera: A Practical Apparatus for Studying the Attention Value of Advertisements," *J. Appl. Psychol.*, 1940, vol. 24, page 417) to study the attention-getting value of pictures or advertisements. It is thought that electro-oculography is now accurate enough to give similar results more easily, and we have already taken records of this type.

Yours faithfully,
B. SHACKEL.

Psychological Research Laboratory,
E.M.I. Electronics Ltd.,
Hayes,
Middlesex.
May 15, 1957.

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THE EXPERIMENTAL SPIRIT

SIR, I was very interested in the series of articles entitled " The Experimental Spirit," which appeared in recent issues of ENGINEERING. In the fourth article, commencing on page 81 of your issue of January 18, there is a reference to the Trofinoff Auto Bye-Passing piston valve.

It may not be generally known that two locomotives on the then London Midland and Scottish Railway were fitted with these valves, a 4-6-0 T.B. 5X class (as they were then) and a 2-6-4 T. class 4 three-cylinder locomotive, No. 2526. The latter locomotive ran on the Tilbury Section before the war and was notable for its extremely free running when coasting, but, after about 10,000 miles running, the floating heads fractured, due to the impact they made with the fixed heads, presumably when the regulator was opened. The first indication of this occurrence was by portions of floating head hitting the driver's spectacle glass, having been ejected from the chimney. The valves were eventually removed and normal piston valves substituted.

The 5X locomotive was similarly altered to take normal piston valves.

Yours faithfully,
W. G. F. THORLEY.

1 Carlyon-close,
Alperton,
Wembley, Middlesex.
May 14, 1957.

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FIRE HAZARDS OF ROOF COVERINGS

SIR, The director-general of the Fibre Building Board Development Organisation is not correct in his letter to you " Fire at Jaguar Works " (ENGINEERING, March 29, page 389) when he

Letters to the Editor (continued)

states that the Fire Protection Association, in one of its publications, confirmed or supported the view that the prime factor contributing to the rapid spread of fire in the roof of the Jaguar factory was the high bitumen content in the roof covering and flashings. The relevant words used in the publication referred to were:—

"Though a strong wind and the flammable contents assisted the fire, spread at ground level was aggravated by burning bitumen and fragments of fibreboard falling from the roof and igniting the materials on the floor."

Yours faithfully,
N. C. STROTHER SMITH,
Director.

Fire Protection Association,
15 Queen-street,
London, E.C.4.
May 14, 1957.

AN ENGINEER'S CARD INDEX

SIR, In these days an engineer is faced with the increasing difficulty of not only absorbing an abundance of newly-published information, but, also, of memorising so many items which he feels may be of future value. When he requires information not contained within the limits of either his memory or his own notes, he needs a library service.

On this latter point Mr. Frank Smith went straight to the crux of the correspondence in his letter "The Blanket of Literature." It is disturbing that so much valuable knowledge is effectively lost to mankind. We worry about the shortage of engineers, but few people, and least of all managements who decide library budgets, worry that so many of them may be repeating work already described in some corner of a vast library of journals, books, and reports. On the former point, that of keeping notes, Mr. R. Silvester's original suggestion for a personally owned index has been amplified by others, until Mr. G. M. Boyd suggests a punch card system. Such a system should, I feel, be unnecessary for individual ownership. It should be reserved for library use. [References to previous letters on this topic are given at the bottom of column 3 on this page.]

It is a good general principle to limit an individually owned index to a small number of entries. I think that a size of 2,000 cards, as mentioned by Mr. G. S. Bahn, is too large: at that stage one would be in danger of duplicating work done by librarians. At the other extreme, Mr. E. Moulijn would almost seem to imply that all subject indexes should be compiled by libraries. I think there is definitely a case for Mr. Silvester's small index, provided its coverage is limited to a specialist division of knowledge too fine to be covered by a library index.

What indexing system then is to be used? There are two main systems. One is the key system, of which the alphabetical index suggested by Dr. J. E. Holmstrom is an example. The other is by the breaking down of knowledge into successively finer divisions, of which the Universal Decimal Classification system suggested by Mr. R. Singh is an example. From my experience of library work and compiling a private index, the latter system is the better, even for a small index. Using it, one can usually determine that the information required is not in certain divisions, but, with the former system, either the wrong key may be used or all the keys leading to the required information may not be thought of. After all, no system should put an added load on our memory, and, with the alphabetical system, headings can multiply and duplicate one another alarmingly.

The U.D.C. system has the advantage of world-wide usage but its headings are rarely sub-divided to a sufficiently fine degree, as even libraries are finding when classifying reports and journal articles. The system we need must above all be elastic. There must be no limitation upon the addition of new headings at any stage in the development of the index, since every individual's interests enlarge with time to cover a surprising variety of topics. Moreover, few individuals will be experienced in the matter when they make their initial choice of headings. Mr. Silvester's proposed scheme does not appear to cover this point.

The U.D.C. system is not by any means elastic because the number of divisions performed at each level is limited to ten. Why, oh why, should it be arbitrarily decided not only to divide all knowledge into exactly ten headings but to limit the number of headings at each and every succeeding level of sub-divisions to ten in number?

An example likely to be readily appreciated by both engineers and librarians is U.D.C. heading 79, "Entertainment. Pastimes. Games. Sport"; which is divided into 10. Because of this 10 limitation, "Games of skill" and "Games of chance," both headings being limited to what we might call indoor games, are each given a three-figure level; "fishing" and "chess" are each given four figures; "sailing" is given five figures; and "cricket" six figures. Or, take division 62, "Engineering and Technology generally." Because of the ten limitation, "Public Health," "Civil," "Military and Naval," and "Mining and Mineral Dressing," engineering each have their own three-figure headings, but Mechanical and Electrical engineering have to share a heading, and Automobile, Shipbuilding and Aeronautical engineering are bunched together as "Transport Engineering."

So I suggest that individuals choose their own subject headings and any necessary further subdivisions in as logical a pattern as they can; keeping it elastic. If a numbering system is needed it should be merely a form of shorthand for the subject headings.

Yours faithfully,
J. G. GIBBINGS.

Department of Fluid Mechanics,
Walker and Harrison-Hughes
Engineering Laboratories,
The University,
Liverpool.
May 14, 1957.

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SIR, I have been very interested in the correspondence under this heading, begun by Mr. R. Silvester's letter; the more so because, since my contribution, I have undertaken to write a paper on "Documentation at the Level of the Individual Scientist" for the International Conference on Scientific Information, which is to be held at Washington in November, 1958. For that purpose, I want to collect as many examples as possible of the various methods which technical specialists in all branches have adopted or evolved for *themselves* for collecting, filing and utilising notes and references. I should be very grateful for descriptions of such systems, and for any ideas and comments that can be brought to my attention, either through the hospitality of your columns, or addressed to me at Unesco, where, originally a civil engineer, I now work as a specialist in the methodology of documentation.

I have italicised the word "themselves" because I do not share the view expressed by Mr. E. Moulijn, that, if the individual engineer or scientist has the benefit of certain services provided for him by a librarian or information officer where he works, it is a waste of time for him to do anything methodical on his own account in the way of documentation. This view seems to me a fallacy. Such services can, indeed, be very valuable in whatever circumstances, and in a research institute they are indispensable; but they are not an end in themselves. Their object is that of helping the individual to select, out of the millions of items of literature that are annually broadcast over the world, and out of the millions upon millions already stored in the world's libraries, those items which are likely to be the aptest for his particular needs, either immediately or in the future; aptest, either as elements for building up the background and providing a recurrent stimulus to his daily thoughts and actions, or as elements to be assimilated with his own ideas and experience when he is originating a new piece of writing.

Whenever a reader receives literature, an abstract, or a bibliographical reference, which makes him say "Here is something I may be able to use," the librarian has done something towards justifying his existence—but not very much, unless the reader takes note of the reference and so disposes of it that it will inevitably come to light if his thoughts should return in that direction. Unless he has some personal device for doing this, or unless it so happens that the item of information is one that he is able to use straight away, he is not likely to remember so much as its existence and that the idea passed through his mind that it might be useful, let alone the exact reference to where it may be found in the library.

Notes and references collected on cards under one's own control, based on unpublished documents as well as on publications received through libraries and independent channels, have also another kind of value, as discussed in my book *Records and Research in Engineering and Industrial Science*, and to which you referred in your leading article of December 21, 1956, page 769: one can pick out those notes that seem to be relevant, and re-arrange and ponder over them in accordance with the pattern of thought that is taking shape in one's own mind.

It has been found from surveys of the reading habits of scientists (which Unesco is now causing to be amplified) that a large proportion of them do, in fact, collect abstracts and other material in card indexes of their own: either in card indexes of the classical type which are dependent on visual searching, or by adopting one or other of the simple systems of punched cards requiring no machinery but operated with inexpensive hand tools. I feel convinced that a comparative evaluation of the various ways the indexing can be done is worth making, governed, I suggest, by three axioms:

(1) As in all filing and indexing, the more time and trouble are applied to the methodical disposal of items of information, the less are involved in ensuring that they come to light when needed. Hence, the attainment of an economic balance in the total effort applied to such operations depends on the *probability* of each particular item being useful at some point in the unpredictable future.

(2) Expenditure of time and trouble on purely manipulative or clerical operations by the collector of the notes himself should be minimised, as, for instance, by using photography, and perhaps, by persuading the publishers of periodicals to supply references with synopses of the articles in a form suitable for adding to a card index.

(3) Whatever operations he does perform should be constructively thought-provoking, not soporific.

Yours faithfully,
J. E. HOLMSTROM,
Department of Natural Sciences.

United Nations Educational, Scientific
and Cultural Organization,
19 Avenue Kléber,
Paris, 16e.
May 15, 1957.

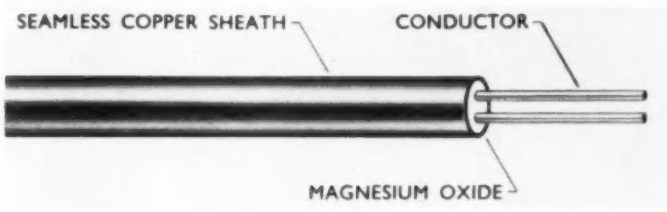
Editor's note: Previous letters on this topic have appeared in our issues of January 11, page 38 (Mr. R. Silvester); January 25, page 101, and February 8, page 165 (Dr. J. E. Holmstrom); March 15, page 326 (Mr. G. S. Bahn); March 29, page 388 (Mr. E. Moulijn); April 12, page 453 ("The Blanket of Literature," Mr. Frank H. Smith); April 19, page 485 (Mr. G. M. Boyd); and May 3, page 551 (Mr. R. Singh).

MAKING "M.I." CABLES

Self-Supporting Wiring for Arduous Conditions

The insulation of cables by means of minerals is by no means new in idea. In 1895 Arnold Borel patented the idea of using a compressed mineral powder to hold wires in position within a tube, the whole assembly to be subsequently elongated by drawing. The patent was never exploited, however, owing to technical difficulties in the filling of the tube. Not until some two or three years ago were these difficulties fully overcome, when British Insulated Callender's Cables, Limited, 21 Bloomsbury-street, London, W.C.1, succeeded in making the process a commercial proposition.

In theory, it follows Borel's patent almost exactly. The powder used is magnesium oxide, otherwise known as magnesia, which has a very high insulating capacity, and is also a good conductor of heat. In the process, the initial tube of copper, 10 yards long and 2 in. internal diameter, carries within it up to seven copper conductors round which the magnesia is rammed. The assembly is then drawn until its outside diameter is reduced to something under $\frac{1}{4}$ in., which is the smallest commercial size made. In the laboratory this size has been reduced still further. The construction is indicated in Fig. 1.



The first operation in the shop is to cut the copper wire for the conductors to the required length and at the same time to straighten it. The cut lengths roll down a slope into their respective bins according to diameter. The outer or "start" tube is cleaned internally, and at one end a guide plug about 8 in. long is inserted which carries holes for the conductors. Tightening an internal screw grips the conductor wires in their holes, and continued tightening expands rubber from within the plug to grip the inside of the start tube. The ram for packing the powder has two sets of three guides just behind the working head to centralise it in the start tube, and the head is drilled to pass over the conductors.

There is clearance between the ram and the start tube and into this annular space the magnesia is poured at a temperature of about 300 deg. C. Previous to pouring the powder is heated in hoppers to a temperature of about 850 deg. C. for a period of not less than three hours. This primary heating is necessary to drive off any moisture, as the powder is hygroscopic. The ram is raised and lowered by a crank mechanism with a short stroke, and the force exerted on the powder within the tube is governed by the spring tension applied to the clamping head which imparts the motion to the ram. As the powder slowly fills the tube, the ram slips through the clamping head, and slowly rises until the start tube is filled. The ramming is carried out with the tubes in a vertical position, as may be seen in Fig. 2. When the tube is filled, it is returned to a bench and the open end stuffed, to prevent the powder from coming out. The start tube, now packed with powder and containing conductors, is taken by a conveyor belt to the next bench, where the plug is removed from the bottom and the whole assembly weighed. The weight (which of course is a measure of the density of packing) is kept constant within about 1 per cent.

The next operation is to swage the bottom end to grip the conductors, and also to form a lead for the drawing processes that follow. Until the length of the drawn tube becomes excessive, drawing is carried out on a horizontal bench through a series of dies which are mounted in a rotating head. After every second draw, the tube is taken, again by conveyor belt, to a roller hearth furnace, where it is annealed in an inert atmosphere. When the tube has become as long as the drawbench, it is passed to a bull block machine with a block 114 in. in diameter. Between all subsequent operations the tube is kept in coil form. The process of drawing is continued until the required size is reached.

Annealing between the draws in this second half of the operation is carried out in bell furnaces. Coils of tube are stacked in a carrier, several sizes being included at the same time. The bell is sealed over the carrier and electric heating is employed in the cover furnace which is again mounted over the bell. Allowing for cooling, the process takes 22 hours. On an average, 20 drawing operations are involved and 10 annealing operations before the cable is complete. After the final annealing, every coil of cable is immersed in water for 12 hours, and tested for insulation. In this way any porosity in the copper outer tube can be detected. Subsequent tests are made for dimensions and electrical characteristics. The ends, that are inevitably damaged during the drawing operations, are cut back and the openings sealed with bitumen. For cables which are liable to be used under very arduous conditions, a sheathing of P.V.C. can be applied. This follows the standard extrusion process with the exception that a vacuum is created between the hot extruded plastics and the copper outer tube of the cable. This gives very tight adhesion of the plastics to the cable. Other materials besides copper can be used for the outer sheath.

Cables are normally made with 1, 2, 3, 4 or 7 conductors in a wide range of sizes. The smallest has conductors of 0·0015 sq. in. section rated at 16 amperes and the largest has 0·20 sq. in. conductors for up to 400 amperes. During the drawing process the conductors are reduced in size in the same proportion as the outer casing. Indeed, if this were not so, the process would not be possible. This deformation of the conductors in accordance with the deformation of the outer casing, provides one of the main advantages of this type of cable. It can be hammered into various shapes, bent round sharp corners to fit into wall spaces, and even forced into the mortar space between bricks to give a smooth finish. Satisfactory operation for considerable periods can be maintained even when the cable is at a red heat in a bunsen flame. The insulating value of the magnesia is slightly reduced at such temperatures, but the properties

Fig. 1 (above) M.I. (mineral-insulated) cables can work under arduous conditions. Materials other than copper can be used for the outer sheath.

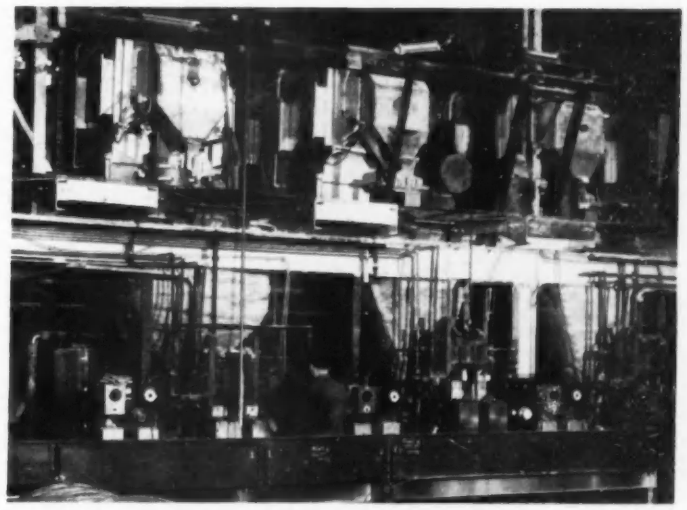


Fig. 2 The magnesia is rammed home with the tube in a vertical position. Behind are the driers for the powder.

Fig. 3 The ramming head is centred in the start tube by two sets of guides. It is drilled to accommodate the conductors. Here, a start tube is being checked dimensionally.

are fully recovered on cooling. Conversely, the conductors can be subjected to enormous overload currents, as the heat generated is carried away by the magnesia and dissipated by the outer copper case. A cable normally rated at 30 amperes will run satisfactorily at 250 amperes and over

The resistance of copper to corrosion makes the cables suitable for use in situations where iron conduit and V.R.I. cables would be unacceptable. The jointing of the cables requires a little skill, but special ferrules are available which seal the ends to prevent the magnesia coming out or becoming moist, and leave the conductors projecting. The fitting of these ferrules is very simple, however, and can easily be carried out on site. A set of fittings (such as fuse boxes, junctions, and the like) has been developed for use with this cable, although it can, of course, be used with other makes. For cost, it compares favourably with a wiring system enclosed in conduit, and the labour involved is considerably less. It is also less liable to corrosion than the steel conduit and is self-supporting.

ALUMINIUM IN ELECTRICAL ENGINEERING

Past Experiences and Future Potentialities

The use of aluminium in electrical engineering dates back for at least half a century. Its application has, however, greatly extended during the past few years; and its employment in future is likely to increase. These considerations led to the organisation by the Aluminium Development Association of a symposium, which was held at the Institution of Electrical Engineers last week; and consisted of the presentation for discussion of 12 papers dealing with economic and general considerations and with the employment of the metal for transmission and distribution lines. Its use in transformers, busbars and telecommunication cables was also described, and there was a small exhibition, and demonstrations of jointing and cold welding.

ECONOMIC CONSIDERATIONS

Dealing with the economies of aluminium in electrical engineering, Dr. E. G. West said that world productive capacity of primary metal in 1955 was 3,478,000 metric tons and it was estimated that this would increase to 5,546,000 metric tons in 1960 and to 6,656,000 metric tons by 1965. The secondary production was about 25 per cent. of the primary production. To develop this output, £1,000 per ton was required and few plants produced less than 10,000 tons per annum. A factor in the cost of production was transportation, but this would possibly be reduced to a negligible porportion of the total, since the advent of nuclear power would enable smelting plants to be located near the ore beds. British consumption of both the primary and secondary metal was higher than that of any other country except the United States. It exceeded 350,000 tons, in both 1955 and 1956, of which some 24,000 tons was used for electrical purposes. Its cost was slightly lower than in many other countries and at £197 per ton was scarcely double the pre-war figure with a possible falling trend.

By comparison with other non-ferrous metals the long term supply of aluminium was particularly favourable, owing to the greater abundance of high grade ores and the establishment of large modern production units. It should continue to be appreciably cheaper than copper for conductors, and should also maintain its competitive position with lead and zinc. The working, jointing, installation and maintenance of aluminium conductors and equipment should be no more expensive than those of copper and lead.

The physical properties of aluminium of interest to the electrical engineer were tabulated in a paper by Mr. C. H. E. Ridpath and Mr. D. F. J. Worth, comparisons being made with copper and cadmium as used for conductors and with lead as used for cable sheathing. The application of aluminium as a constructional material for casting and wrought forms was also described and some notes were given on the welding processes that were available.

In dealing with jointing processes for aluminium Mr. J. C. Bailey and Mr. P. Gregory said that practical methods included fusion and resistance welding as well as brazing and compression jointing. Aluminium was outstandingly suitable for jointing by the aid of pressure and deformation since the oxide film was easily ruptured, thus exposing clean, unoxidised surfaces with good contact properties. The development of this process might lead to methods which were entirely new.

HIGH VOLTAGE TRANSMISSION

Mr. G. B. Jackson described the application of aluminium and its alloys to the high voltage transmission lines of the Central Electricity Authority, under the headings of supports, conductors and accessories. Their employment for supports was limited, but allowed the weight to be reduced and might lead to an increase in life owing to their self-protective properties against corrosion. On the other hand, steel-cored aluminium had been used for the majority of the Authority's overhead conductors and details were given of both standard and special designs, such as those employed at river crossings, for long spans and for experimental purposes. The last included conductors with sheaths in replacement of either of the outer or the inner aluminium strands. The steps that had been taken to provide protection against corrosion were also described and details were given of the various accessories, such as clamps and spacers, which were employed.

Mr. R. Cloke and Mr. R. Fyfe pointed out that aluminium conductors in various forms could be substituted for copper for overhead distribution lines with appreciable economies in first cost. All-aluminium was most suitable for low voltage lines, while for high voltage lines the choice lay between steel-cored aluminium and a high tensile alloy, the latter being generally most suitable. Where very high strength was required, such as in the replacement of existing steel conductor lines, steel-cored high tensile aluminium alloy was both practicable and economic, besides considerably increasing the electrical capacity.

Mr. G. F. Peirson described the problems which had been encountered by the Midlands Electricity Board in using cables with aluminium conductors on their medium voltage systems. These particularly related to jointing and were solved by the careful choice of material and the development of new techniques. In the course of these investigations the limitations of the soft soldering technique and of fluoride type fluxes were brought out, as were the disadvantages of reaction soldering. As a result of the employment of aluminium for underground cables, however, some £170,000 had been saved in 1955-56. Both cables and joints had performed their duty satisfactorily and gave every indication that they would continue to do so.

TRANSFORMER WINDINGS

In assessing the economic advantage of using aluminium instead of copper for transformer windings, Mr. F. W. Gee and Mr. R. J. Gresley pointed out that the cost of the core steel and the capitalised cost of the losses must also be taken into account. The variability of the cost factor made any general statement misleading, except to say that any advantage was marginal. At present, aluminium was an economic alternative to copper for power transformer windings in some cases; and the future might still further swing the balance in its favour. Manufacturing difficulties had been overcome, but help was needed from the metallurgist in extending our knowledge of the basic properties of the metal. The co-operation of users was also necessary.

Although aluminium had been used for busbars for more than 30 years doubts still existed, said Mr. A. R. Parish, about its mechanical properties and its jointing. Special alloys with substantially improved mechanical properties had now been introduced. Jointing, however, still remained a problem, although the use of a proprietary compound for this purpose seemed to have great promise. Lower conductivity and lower strength, relative to copper, had also been obstacles to the use of aluminium for busbars, but the latter was much cheaper at the present time.

JOINTING PROBLEMS

Jointing was also referred to by Mr. R. C. Mildner and Miss B. F. Thorne as a particular obstacle to the use of aluminium in telecommunication cables. It was fairly certain, however, that it would be more extensively used than in the past, especially for subscribers' distribution cables. For broad-band carrier telephony over air-spaced coaxial cable it was likely to remain unattractive as a sheathing material until a simple non-mechanical joint had been developed and an effective protection against corrosion had been found. Aluminium would also continue to play an important part as sheathing material in the radio and television fields. In a cable recently laid as an experiment by the Post Office between Dover and Deal, aluminium conductors 0·044 in. in diameter had replaced 0·036 in. copper conductors, thus giving a saving in weight of about two-thirds and a reduction in cost of 30 per cent.

Dealing with aluminium in the British telephone service, Mr. J. Gerrard and Mr. T. P. A. Urben said that it showed little advantage for small gauge conductors in subscribers' circuits. In the heavier gauge trunk or junction cables its lower cost compared with copper might be an economic advantage, in spite of the larger amount of duct space required. It was also showing promise for sheaths for screening cables against interference and in the construction of die-cast frames of complex form. The application which consumed the largest quantity was for the spacing of the contact assemblies where its ability to flow under pressure was used to accommodate dimensional differences in the contact and insulating segments. By this means the complete assembly of 60 layers of components could be constructed to very close overall tolerances.

FRENCH AND GERMAN EXPERIENCES

Finally two papers were presented on experiences with the use of aluminium in France and Germany. In the first of these, M. P. Jacomet said that the severe shortage of copper between 1941 and 1946 had resulted in its replacement by aluminium for windings without any other modification. The consequence was a reduction in output of 20 per cent. and a considerable increase in leakage losses. Aluminium had been unjustly blamed for the disastrous effect of chlorinated dielectrics (which were used for cooling transformers instead of oil) on the poor quality insulating materials. In spite of this, large numbers of these machines were still operating satisfactorily.

In Germany said Dipl.-Ing. W. von Zwehl the consumption of aluminium for electrical uses amounted to 37,600 metric tons, or about 16 per cent. of the total. Of this consumption, 20,300 tons was for wire and cables and 15,900 tons for machines and apparatus, the latter consisting mainly of castings from secondary alloy. Practice with regard to the application of aluminium for overhead lines, insulated cables, busbars and constructional purposes was similar to that in other countries.

FATIGUE AND CREEP PROPERTIES OF PLASTICS LAMINATES

The better fatigue properties that are shown by reinforced plastics over aluminium alloys, particularly in the matter of notch sensitivity, was one of the points stressed in a paper by Mr. A. W. Thompson of Bristol Aircraft Limited, presented at the third conference on Reinforced Plastics, held by the British Plastics Federation at Harrogate from May 1 to 3. The conference was under the chairmanship of Mr. W. Andrew Baker, deputy chief development engineer (plastics) of Bristol Aircraft Limited, and chairman of the Federation's Reinforced Plastics Technical Committee. Some 140 delegates, comprising chemists, research personnel, engineers and technicians from all branches of the industry and from user firms and Government research establishments, attended.

In the course of his paper, which was entitled "The Fatigue and Creep Properties of Plastics Laminates," Mr. Thompson stated that a significant conclusion drawn from a study of previous work on fatigue tests of glass-fabric base plastics laminates had shown that this material was not sensitive to notch effect. This was of the highest importance and meant that the fatigue strength for use in design could be a high proportion of the full material strength since large allowances for the effect of poor surface finish, stress raisers due to sudden changes of section, and surface damage in service, were not required. Another conclusion was that plastics structures were safer in use than aluminium-alloy structures since the effect of accidental damage in the structural strength was not so great.

Plastics laminates had thus been shown to possess some most encouraging fatigue properties, and it appeared that further work would be justified. Accordingly, research was put in hand employing four resins, namely, one polyester, one phenolic and two epoxide materials. Low alkali satin-weave glass cloth to specification D.T.D. 5501 (now D.T.D. 5518/S2/225/E) was employed. The bulk of the work on axial-loaded fatigue was conducted on a machine running at a speed of 100 cycles per minute, but a machine having a minimum running speed of 1,000 cycles per minute was also available and was used for tests in the low stress-long life range. Moreover, tests by repeated flexural loading at 2,850 cycles per minute were carried out, as were also creep tests on each of the laminates chosen for fatigue testing.

Laminates were made in two thicknesses, normally $\frac{1}{8}$ in. and 0·30 in., and, from these, test specimens had been cut to shape on a band saw and finished to the required dimensions on a profile milling fixture.

The work so far accomplished had covered only a part of the first stage of a complete investigation, but certain broad trends had emerged. For the purpose of design investigations two reasonable assumptions could be made.

In the first place, a plastics laminate should withstand 10 million cycles of a load not exceeding one-fifth of its ultimate tensile strength, providing that the laminate had not "crazed" on the initial application of the load. In the second place, a laminate should hold continuously a load of some two-thirds of its ultimate load for six weeks at least and probably considerably longer. Moreover, it would not creep appreciably under this load during this interval of time. Furthermore, the results indicated that only a slightly reduced load could be held for a year or more.

The crazing mentioned had led to research into the properties of numerous resins to establish which were most likely to give laminates of high fatigue strength; work in this direction was still proceeding.

DIESEL LUBRICANTS

The requirements of lubricants for Diesel engines are dealt with in a paper given by Mr. A. Dyson, Mr. L. J. Richards and Mr. K. R. Williams, all of the Thornton Research Centre of the Shell Group. The paper was presented to the Institution of Mechanical Engineers on May 17.

In recent years, the authors observe, substances have been added to heavy-duty lubricating oils to prevent fouling, corrosion and wear. One of the principal requirements is that the oil shall possess a considerable degree of alkalinity to counteract the sulphur acids formed during the combustion process. Naturally, the quantity of this varies with the quantity of sulphur in the original fuel, and it is partly true to say that the destruction of the alkalinity level is proportional to the total throughput of sulphur. The level naturally falls during service, and is partially restored by make-up oil. A very definite amount is needed to prevent fouling on the top lands of the piston, as it is in this region that the acids are first formed. Acids going into solution in the oil can be carried round and can attack the bearings if they are not first neutralised by the presence of an additive. The authors of the paper suggest that the condition of an oil can be gauged by measuring its alkalinity, and give the warning that the change point, after which rapid deterioration occurs, can be very sharp, and that therefore the renewal of oil on a time basis can in some cases require to be very exact.

In their conclusions the authors state that it is possible from their work to relate additive depletion to various engine design and engine operating factors, and thereby ensure satisfactory results with additive-type lubricants, thus ensuring the most economic application of the lubricating oil. With many heavy-duty oil formulations the concentration of alkalinity may be used as a criterion of the effectiveness of the additives. Two-stroke engines and four-stroke engines with pre-combustion chambers give higher neutralisation rates than do four-stroke injection engines. Although most of the work has been done using medium and high speed Diesel engines and distillate fuels, the authors believe that their conclusions are valid if fuels containing residual components are used. While the results may only be approximate, they have proved successful in predicting engine oil requirements.

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SHRINKING IT IN

During the fabrication of a capstan for a large ocean tanker at the Dunston-on-Tyne factory of Emmerson Walker Limited, it was found necessary to make the main steel shaft in two units. The screwed extension, which has a square thread and is used for raising or lowering the shaft to engage and disengage the clutch, had to be turned as a separate part.

Initially, it was decided to expand the shaft so that the two parts could be joined. Due to varying thicknesses of metal, however, the expansion obtained would have been uneven, and after consultation with British Oxygen Gases Limited, the firm decided to employ liquid nitrogen to shrink the screwed extension so that it would fit into the main shaft. The shaft was 15 ft. in length, with a diameter of $11\frac{3}{4}$ in., and the weight was $2\frac{1}{2}$ tons. It was positioned vertically in its main bearing and the extension was to be inserted at the top of the shaft. The extension was 8 in. in diameter and had been turned to give 0·003 in. interference. After immersion in liquid nitrogen for a period of 45 minutes, a micrometer reading showed that the part had shrunk to 7·995 in., which allowed 0·005 in. clearance. The extension was then lifted by overhead crane and dropped into the end of the shaft which was recessed 3 in. to receive it. Air vents had been cut in the extension, and it was later drilled and pinned in position.

Subsequently the firm used the same process to shrink another capstan shaft and a total of 90 lb. of liquid nitrogen was used for the two operations. Had the two shafts been set up side by side, however, only 50 to 60 lb. of liquid would have been used.

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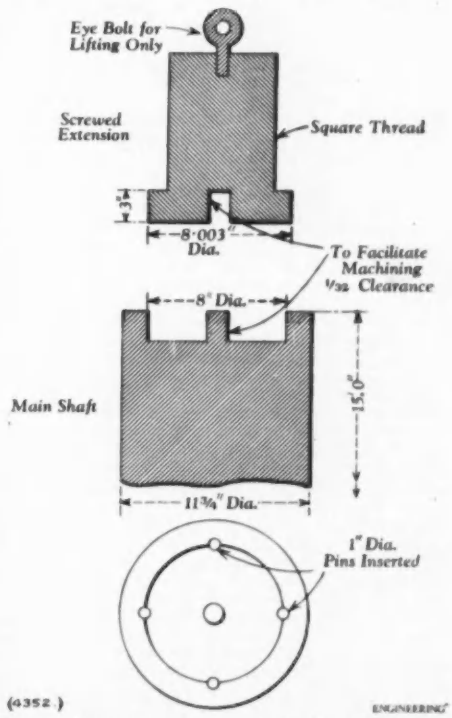
TRANSATLANTIC TELEPHONE CABLE

The telephone cables, which were laid in the Atlantic and were brought into service in September, 1956, to provide better communication between this country, Canada and the United States, have proved so successful that it has been decided that another shall be provided as soon as possible. This will be employed principally to deal with the Canadian traffic, which has trebled during the past six months. The new cable, unlike its predecessors, will be exclusively a Commonwealth enterprise. It will be about 1,900 miles long, will be manufactured in this country and will contain from 50 to 100 repeaters in order to provide 60 two-way telephone circuits. This development from the 36 voice circuits which can be carried in the existing cables, is due to the fact that the British "hard" type of two-way repeaters are to be used, an interesting advance in technique and manufacture, which will impose considerable practical prolems during installation.

The quality of these repeaters has, of course, already been proved, but to deal with them will probably necessitate modifications in the laying gear of H.M.T.S. Monarch. These difficulties will, however, be compensated to some extent by the fact that the main length of cable between Scotland and Newfoundland will cost only about two-thirds of its predecessors. It is stated that orders for the main cable are expected to be placed shortly with a British firm and that the connections westward from the Newfoundland terminal, which will be the responsibility of the Canadians, will also be manufactured in this country. It is expected that the cable will be completed in 1961 as a joint undertaking by Cable and Wireless, Limited, and the Canadian Overseas Telecommunication Corporation.



To enable a screwed extension to be fitted to the main shaft, it was shrunk by immersion in liquid nitrogen.

ULTRASONIC TESTING OF HEAVY STEEL PRODUCTS

PROBLEMS IN APPLICATION AND INTERPRETATION

By I. M. Mackenzie, B.SC., *and R. Kennedy*, B.SC., PH.D., A.R.T.C.*

During the past few years there have been notable advances in the techniques for the detection of flaws in metal products by ultrasonic means, but the rate of progress in the application of these potentially useful methods to the non-destructive testing of heavy steel products may appear surprisingly slow. While it is true that in an old-established industry, such as the steel industry, there is liable to be a conservative attitude towards the introduction of new testing methods, it is the purpose of this article to discuss some of the difficulties which are facing the steelmaker in his attempts to apply ultrasonic tests to heavy steel products.†

The engineer has come to rely on steel because of ts strength and ductility and the relative ease with which it can be fabricated, and it is the object of the steelmaker to avoid supplying material containing defects which may render it unsuitable for fabrication or service. Since the propagation of ultrasonic waves depends on the mechanical properties of the material, flaws which would affect the mechanical properties are usually detectable by their effect on ultrasonic waves. It does not follow however that everything affecting the propagation of ultrasonic waves is necessarily a flaw, justifying the rejection of material. Long experience has taught metallurgists and engineers to distinguish between defects which will or will not influence the behaviour of the metal in fabrication and service. It is known that certain types of discontinuity can be tolerated, at least when they are few in number and small in magnitude, and appreciation of this has permitted steelmakers to simplify and cheapen steel production. If the ultrasonic test is to be useful it must therefore enable the inspector to discriminate between harmful defects and unimportant imperfections, and the general problem is to devise ultrasonic tests which will identify defects and provide means of estimating their magnitude. While considerable progress has been made towards the solution of this problem on a laboratory scale, certain difficulties must still be overcome before ultrasonic methods can be accepted for the routine testing of the large tonnages of steel which are produced daily in a modern works.

Attempts have been made to apply ultrasonic testing to a wide variety of heavy steel products, including as-cast and hot-worked steel in the form of ingots, plates, bars, blooms and forgings. The types of discontinuity usually encountered in such products may be classified under three main headings: (*a*) contraction cavities or blowholes which may be partially or completely flattened due to hot working operations; (*b*) cracks; and (*c*) entrapped non-metallic matter which may be in the form of globules, rods or platelets. In general, large discontinuities will obstruct and reflect ultrasonic waves, while smaller imperfections will cause scattering of the wave beam. The interpretation of ultrasonic tests, however, is complicated by the fact that the propagation of ultrasonic waves may also be affected by diffraction and reflection at the boundaries of anisotropic crystals and by variation in composition over macro and microscopic distances. Moreover, heavy steel products invariably have relatively rough surfaces, which may be covered by adherent or partly adherent scale, so that the conditions for transmission of ultrasonic vibrations to the metal are far from ideal. For economic reasons preparation of the surfaces before testing is impracticable.

As already indicated it is generally the large discontinuities such as cracks, holes and gross non-metallic particles which would affect the behaviour of the metal in fabrication and service. This point requires to be stressed since the problem of distinguishing between the effect of such major flaws and effects attributable to relatively numerous small discontinuities or anomalous propagation forms one of the main stumbling blocks to the interpretation of test results in many instances.

TECHNIQUES

Types of ultrasonic testing equipment have been designed employing continuous wave transmission, but this system has not been particularly successful, principally due to the difficult es which arise in the interpretation of the results obtained because of interference effects and the formation of standing waves in the material under test. Most of the commercially available instruments employ pulsed-wave systems which overcome many of the difficulties encountered in continuous transmission, since the reflections from one pulse die out before the succeeding pulse is emitted.

There are two basic methods which may be employed in testing, namely transmission and reflection techniques. The former depends on the obstruction which a flaw offers to the passage of waves through the material, while the latter method is based on the detection of waves reflected from the flaws. It is immediately obvious that in the case of the transmission method the presence of a large flaw leads to a negative indication, i.e., the disappearance or a reduction in the intensity of the transmitted signal. A similar effect is, however, produced by the presence of minor inclusions, variation in composition, poor linkage between the probes and the object under test, or misalignment of the probes, and it is not easy to interpret the results.

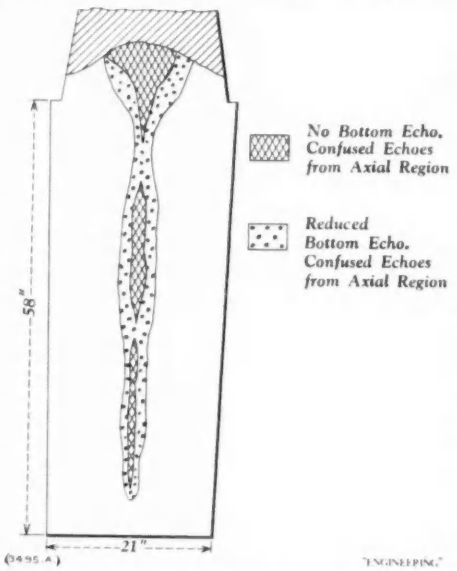


Fig. 1 Result of ultrasonic test on 4 ton ingot, showing areas where the echoes are confused.

Reflection methods, in which the echoes of an ultrasonic pulse are shown as deflections of the trace on an oscillograph, give a positive indication of the presence of major flaws and can provide valuable information regarding their magnitude and location. Although scattering and variation in surface contact affect the results, the presence or absence of an echo from the far surface of the object can often be used to confirm that satisfactory penetration is being obtained. It is also possible to make a rough estimation of flaw size from the relative amplitudes of the "bottom" and "flaw" echoes. Thus the disappearance of the "bottom" echo and the appearance of a large "flaw" echo would indicate a major defect, while an oscillograph trace showing a slightly reduced "bottom" echo and small "flaw" echo would indicate a relatively minor discontinuity. This estimate of flaw size is, however, purely qualitative even under the best conditions of test, since the reflection is dependent on the shape and orientation of the flaw. The use of standard test blocks as a means of determining the sensitivity of ultrasonic flaw detectors and of estimating defect size has been advocated, and has been successfully applied for testing non-ferrous materials. Such reference standards are not particularly useful in the interpretation of tests on steel. Apart from the fact that "standard flaws," which usually consist of drilled holes, bear little relationship to the defects sought in practice, the variation encountered in surface condition, crystallographic structure, metal composition and content of non-metallic inclusions, is such that no universal standards can be employed when testing heavy steel products.

APPLICATIONS

Because of difficulties in interpretation, ultrasonic testing has had its greatest success in cases where it has been possible to employ personnel skilled in the use of ultrasonic apparatus and at the same time possessing experience of the metallurgical characteristics and requirements of the material tested. If ultrasonic methods are to be extensively applied to steel products, however, there is obviously a limit to the use of skilled operators and the introduction of a certain degree of mechanisation is essential, One of the problems confronting the steel industry is, therefore, to devise tests which are at the same time speedy and economic to carry out. Some of the methods which have been suggested for automatic flaw detection will be discussed later.

The heavy steel industry is faced with a number of inspection problems in which ultrasonic methods may ultimately prove to be of assistance. Some of the more important potential applications are as follows: (*a*) detection of laminations in plates; (*b*) detection of pipe and segregation in round and square bars; (*c*) detection of pipe and contraction cavities in ingots, blooms and forgings; and (*d*)

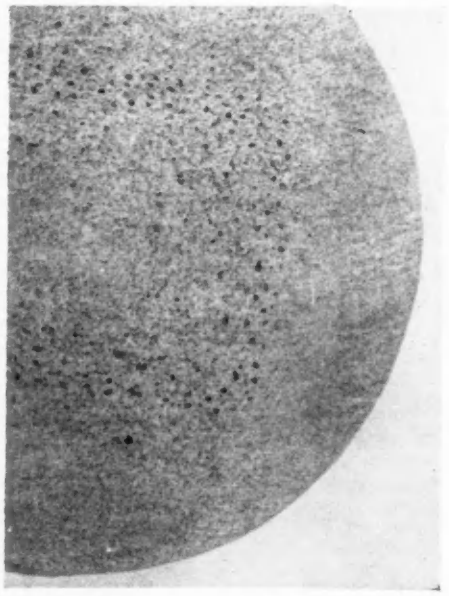


Fig. 2 Sulphur print (half actual size) of steel bar showing harmless "ingotism," which echo testing can confuse with piping.

Fig. 3 Macro-etched section (actual size) of mild-steel plate, showing hairline cracking. Such a defect is clearly shown by ultrasonic testing.

* Of Colvilles's Research Laboratories, Motherwell, Scotland.

† Based on an unpublished paper originally delivered to the Non-destructive Testing Group of the Institute of Physics in Glasgow on June 24, 1955.

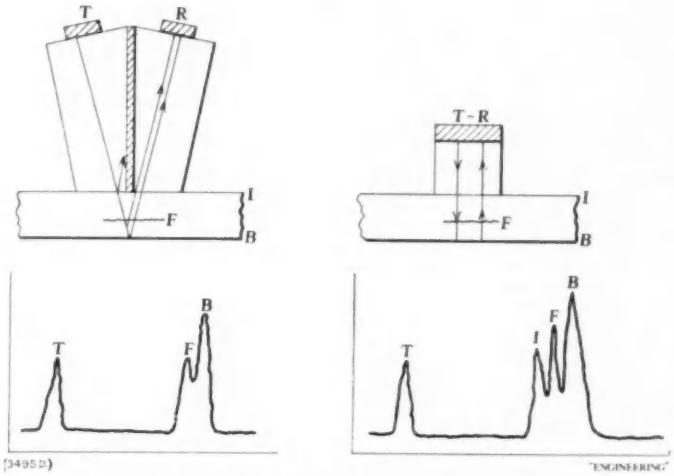


Fig. 4 Diagram showing use of dual-wedge probe and single transceiver probe for testing thin plates for laminations.

detection of hairline cracks in plates and billets. Experiments on the application of ultrasonic testing methods in these fields have been carried out using a number of proprietary equipments, with which it has been possible to investigate various flaw-detection techniques. The following examples from practical experience illustrate some of the difficulties encountered in the application of ultrasonic tests.

DETECTION OF PIPE IN INGOTS

One of the advantages claimed for ultrasonic methods is that they are suitable for the detection of flaws in large masses of steel. The ultrasonic testing of steel ingots, however, raises problems which have not yet been satisfactorily overcome. In the case of balanced and rimming steels, ultrasonic examination is impracticable due to the presence of subsurface blowholes originating from gas evolution during solidification. Attempts have been made to determine the extent of piping in killed steel ingots by ultrasonic means, but two main problems arise in this application.

It is invariably found that the surface of a steel ingot is very rough and the difficulty of establishing satisfactory contact between a probe and such a surface is naturally great. A more fundamental difficulty arises from the manner in which steel solidifies in a cast-iron ingot mould. As the rate of extraction of heat from the liquid metal is initially rapid, the surface of the ingot consists of columnar crystals oriented with their major axes at right angles to the ingot surface. Such columnar crystals form a barrier to ultrasonic waves and in extreme cases it has proved impossible to transmit ultrasonic energy through them at all. In the case of steel with a low alloy content, the difficulties are not so great, but there is still considerable dissipation of the beam due to the periodic variation in the composition of the metal due to selective freezing. It is therefore necessary to pass a very considerable amount of energy into an ingot and operate at high sensitivity in order to get a detectable echo from the far surface. This would not matter were it not for the fact that even in the case of a good ingot there are sufficient minor contraction cavities about the central axis to reflect a considerable proportion of the ultrasonic energy. Consequently, even in the case of a good ingot, echoes are received from near the central axis and in testing ingots for pipe it is necessary to decide whether the echo is coming from a gross shrinkage cavity or from these small and unimportant defects. The acoustic impedance of ingots is so variable that it is found in extreme cases that the magnitude of the echo from the central axis of one ingot may be greater than the signal received from gross pipe in another, while a third may prove impossible to test.

This difficulty in interpretation was illustrated in the examination of several four-ton ingots, the surface of which had been machined to improve the test conditions. The ingots were tested using both a separate transmitter-receiver instrument, operating at 2¼, 1¼ and ¾ megacycles, and a single transceiver probe instrument employing a frequency of 2 megacycles. It was found that even when using the lowest frequency, echoes were obtained from the central region of the ingot over practically the whole of its length, and the reflection from the central axis was so marked that no bottom echo could be obtained over the major part of the length. It was not possible to discriminate satisfactorily between the traces obtained at the top of the ingot, corresponding to primary pipe, and those obtained near the base where there is only minor porosity. Typical results obtained using the single two-megacycle probe are shown in Fig. 1. It is possible that the development of higher power transmitters and the use of considerably lower frequencies may contribute to the future solution of this particular testing problem.

FORGINGS AND BLOOMS

The difficulties in testing forgings and rolled blooms are not quite so great since heating to the hot-working temperature has given an opportunity for diffusion, which makes the composition more uniform, and since the hot deformation seals up many of the smaller cavities within the metal. Rolling and forging operations have their greatest effect on the metal near the ingot surface and deform the columnar crystals so that they offer less obstruction to the passage of ultrasonic waves. In the case of blooms, the success of testing depends to some extent on the degree of reduction during cogging. Smaller blooms which have undergone considerable reduction in section are usually reasonably easy to examine. It is possible, however, to obtain anomalous results when testing large blo, ıs. This was demonstrated in tests on a 20 in. square low-alloy steel bloom which was suspected to contain gross contraction cavities near the central axis. This bloom, which weighed about 10 tons, proved very difficult to test, and the only technique whereby a bottom echo could be received was to employ half-megacycle mosaic probes. Using this technique it was possible to detect the presence of contraction cavities extending from one end of the bloom more than half-way along its length and this was later confirmed by sectioning. It was also found that when the bloom was tested near the edges similar indications were obtained at some points from positions approximately half-way through the thickness at which no visible defects existed. These reflections could only be attributed to some type of compositional or structural variation, a fact which emphasises the difficulties facing the operator of ultrasonic equipment when testing this type of product.

Despite these difficulties much useful work has been done with the ultrasonic testing equipment to detect and locate defects in forgings and castings. The examination of heavy forgings is perhaps one of the most successful applications. Conditions are favourable to ultrasonic techniques since the structure of forgings is relatively homogeneous compared with that of ingots and blooms, so that penetration can be obtained through large thicknesses with little interference. It is also possible in this application to carry out a detailed skilled examination since the time spent in testing is amply repaid by the detection of defects before machining is undertaken.

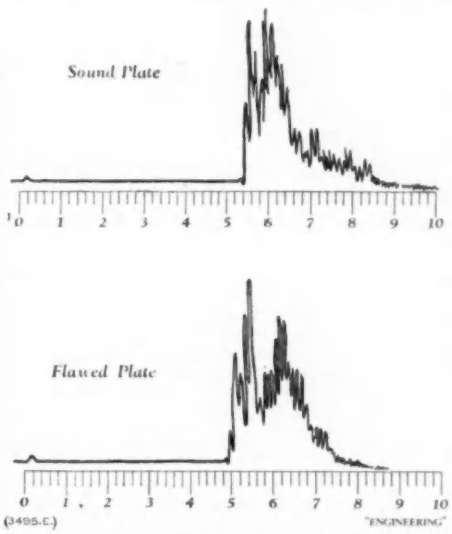


Fig. 5 Oscillograms from sound and flawed ½ in. plates using a dual-wedge probe.

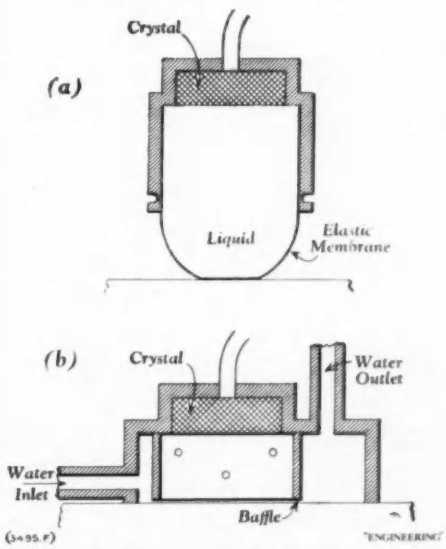


Fig. 6 Suggested probes for continuous-wave through-transmission testing.

DEFECTS IN BARS

In the early stages of development of ultrasonic equipment, a considerable amount of experimental work was carried out with the object of determining the extent of pipe and segregation in steel bars. Usually, the presence of pipe is readily detectable by the reflection technique, but it is not easy to set up acceptance standards. In some cases the ultrasonic test was deemed unsatisfactory because it did not correlate with the sulphur print test, though it is possible that in many cases it gave an equally reliable indication of the presence of harmful defects. Difficulty may be experienced occasionally in the case of bars which show a pronounced though often harmless form of segregation known as "ingotism." This characteristic segregation pattern, which is illustrated by the sulphur print reproduced in Fig. 2, is evidently formed at the junction of two zones of solidification and ultrasonic waves are strongly reflected from this junction. Apart from a small difference in the location from which the echo is received, the indications from bars showing "ingotism" are very similar to those from bars which are piped and there have been cases where sound material was wrongly condemned on the basis of the ultrasonic test.

DETECTING HAIRLINE CRACKS

One field in which ultrasonic methods have achieved considerable success is the detection of hairline cracks in forgings, bars and plates. Hairline cracks are encountered in incorrectly heat-treated medium carbon and alloy steels having a relatively high hydrogen content. The appearance of a typical sample is shown in Fig. 3. The orientation of the small cracks is favourable for the reflection of an ultrasonic beam travelling from the surface and badly affected material is easily distinguished by ultrasonic testing without the necessity for cutting and grinding sections for examination in a magnetic crack detector. In this case it is unnecessary to test the whole of the material since it is usually known that if cracks are present at all they will be found near the longitudinal axis of the ingot and a test in this region may be taken as being representative of the material.

LAMINATIONS IN PLATES

The problem of devising non-destructive tests for the detection of laminations in plates is one with which the steel industry is particularly concerned. Laminations, as their name implies, are defects which separate the plate into two or more layers. The separation may be due to imperfect sealing of contraction cavities or to the presence of non-metallic matter which has been rolled out with the metal to form a lamellar defect. Laminations are most commonly found about the centre of the plate thickness near the pouring line, but sometimes they occur in other positions. Their dimensions vary from insignificantly small defects to areas several inches across, but it is only the major defects which render the plates unacceptable.

When plates were used in riveted construction laminations seldom impaired the serviceability of the material, but the situation has changed radically

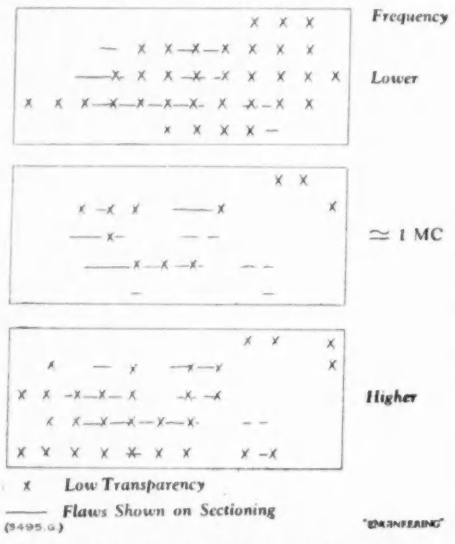


Fig. 7 Variation in transparency of ½ in. mild-steel plate with alteration in transmitter and receiver frequency, using continuous-wave equipment. The correlation is not good.

with the introduction of welding. In many structures stresses are transmitted through fillet welds and there are tensile stresses through the plate thickness. It is obviously undesirable to have the plate weakened in this direction by laminations. In cases where lamination is due to the presence of entrapped oxides difficulties may be encountered in producing sound butt-welded joints, since the molten weld metal reacts with iron oxide, evolving gases which cause porosity and cracking in the weld deposit. Increasing presssure is therefore being put on steel-makers to supply special quality plates free from gross laminations. At present the only practicable method of detecting them at the steelworks is to examine the edges of the plates. Laminations located at the edges are usually detectable if the plates are gas cut but only a small proportion of the plates are cut by this means, the majority being sheared, and unfortunately the action of the shear blades tends to disguise the presence of laminations. In the past there has been no means of detecting laminations within the body of plates.

ECHO TECHNIQUE FOR THE DETECTION OF LAMINATIONS

Ultrasonic methods should be particularly suitable for the detection of lamination in plates since the defects are orientated in the most favourable manner with respect to the plate surface. Using the echo technique, the test can be carried out from one surface of the plate either with a single probe functioning both as transmitter and receiver or with separate transmitting and receiving probes. Since an echo is received from the bottom surface of the plate it is possible to keep a check on the efficiency of surface contact. The presence of a lamination is indicated by an echo coming from a source within the plate and the magnitude of the defect can be estimated semi-quantitatively by comparing the relative magnitude of the flaw and bottom echoes. It has not yet been possible to apply this method to the routine testing of large numbers of plates because of two outstanding problems. In order to ensure freedom from laminations it is essential that the ultrasonic test be carried out over the whole area of every plate. If this involved moving the probe slowly over the whole plate surface while an operator watched the oscillograph screen for a change in the pattern of the trace, the method would impose such a strain on the operator and be so slow that the test would be prohibitively expensive to apply. To make the test suitable for application to large tonnages of plates, it is therefore essential that methods of automatic scanning and monitoring be developed. One method of doing this is to employ an electronic device which indicates the reception of a flaw signal during the time interval between the transmitted pulse and the bottom echo by operating a warning mechanism such as a light or hooter. A shortcoming of the above system is that no indication of a flaw is obtained in cases where surface irregularity leads to inefficient transmission of the ultrasonic waves between the probes and the plate. There is also the problem of setting the instrument in such a way that it will discriminate between minor and major flaws despite variations in the absorptive properties of the plate material.

In the case of plates above about 1 in. in thickness there is no difficulty in applying the above technique, since there is an appreciable time interval between transmission and reflection of the ultrasonic pulse. In the case of thinner plates, however, the duration of the pulse may be commensurate with the time of travel within the plate so that the echo from a lamination may return to the surface while the pulse is still being transmitted. Thus the time intervals between the initial pulse, flaw echo and bottom echo are very small and it becomes increasingly difficult to interpret the resulting oscillograph pattern.

This disadvantage may be overcome by using suitably designed separate transmitting and receiving probes, introducing the ultrasonic beam at a slight angle. With this arrangement the returning echoes may be separated from the initial pulse by the insertion of wedges between the crystals and the surface of the plate, as shown in Fig. 4. This is not practicable with a single transceiver probe since reflections would be received from the upper surface of the plate which would further complicate the oscillograph trace. The geometrical arrangement of the dual probes, however, eliminates such reflections from the receiving crystal. With correctly designed dual probes satisfactory results may be obtained on plate thicknesses as low as ¼ in. The types of trace obtained with the separate transmitter and receiver probes on sound and laminated plates ½ in. thick are shown in Fig. 5. It will be noted that the flaw echo appears very close to the bottom echo, making visual detection of defects difficult, especially if a rapid scanning rate is employed. This, however, does not offer any difficulty if electronic monitoring of the oscillograph trace is employed.

Alternative methods have been developed for the

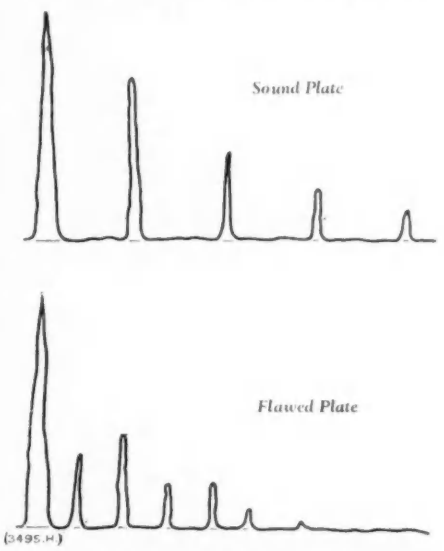


Fig. 8 Oscillograms obtained with multiple-echo testing. Laminations are clearly distinguished.

detection of laminations in thin plates. The results of experiments to assess the reliability of some of these techniques for the routine testing of mild-steel plates, ranging from ¼ in. to 1 in. in thickness, are given later.

TRANSMISSION TECHNIQUES

Methods involving transmission of the ultrasonic waves through the plate are attractive since they avoid some of the difficulties encountered with the reflection method, particularly when applied to the testing of thin plates. Transmission methods are also the most easily adapted for automatic monitoring, since the intensity of the transmitted beam may be measured directly and used to operate some form of low transparency indicator.

Experiments have been carried out with an equipment employing continuous-wave transmission. In this case separate transmitting and receiving probes are placed on the plate surfaces directly opposite one another and the intensity of the transmitted wave is indicated on a micro-ammeter. If a lamination is present there is a drop in the transmitted energy because the vibrations are reflected and damped by the lamination. The theory of this method is complicated by the fact that the major proportion of the energy passing through the plate is reflected at the surfaces and thus continues to vibrate the material. The acoustical energy measured by the receiving probe is therefore derived not only from the directly transmitted vibrations but also from those which have been reflected across the plate many times. Such multiple reflections may give rise to standing waves within the plate which alter the amplitude of the vibrations.

One of the major problems encountered with this method was that of maintaining constant efficiency of surface contact. The best procedure would be to immerse the plates completely in a suitable fluid such as water, but this would not be practicable for the testing of large plates of variable size and thickness in a steelworks. The original design of probe, shown in Fig. 6(*a*), consisted of a water-filled tube closed by a distended elastic membrane which could be pressed into intimate contact with the plate surface. While this proved satisfactory for laboratory use, the probes could not be slid rapidly across the plate surface and were therefore unsuited for routine works testing. Another form of probe, in which a water column was maintained between the probe and plate by a continuous water feed, was found to give erratic results which were traced to the effect of turbulent flow of water within the probes. By the insertion of internal baffles probes were finally devised (Fig. 6(*b*)) which maintained a quiescent water column between the crystal and the plate, and it was found that reasonably constant transmission efficiency could be maintained with this probe provided that the plate surfaces were free from loosely adherent scale.

Despite the improvement in surface contact, the results obtained with this apparatus were not satisfactory. The equipment had been designed to operate at frequencies between 0·95 and 1·05 megacycles and despite the fact that frequency modulation was employed to eliminate standing

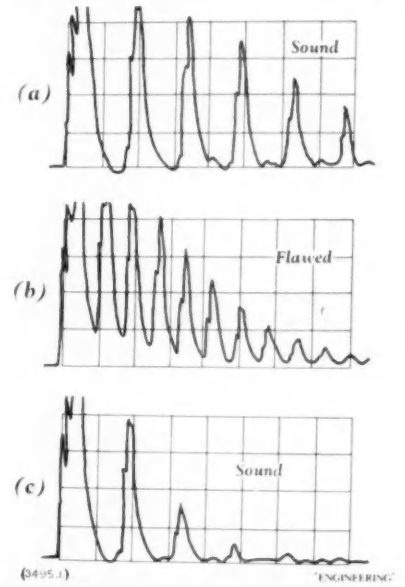


Fig. 9 Oscillograms obtained from ¾ in. plate, using multiple-echo technique.

waves, it was found that alteration in the frequency setting had a marked effect on the results. This is illustrated in Fig. 7 which shows the indications obtained on testing a single sample of plate at three different frequencies. The correlation of the results obtained with different frequencies is by no means good. The plate was subsequently sectioned and examined metallorgaphically and it was found that while all three frequencies indicated the presence of major defects, there were localities at which tests with one or more of the frequencies gave indication of defects although nothing could be observed by metallographic examination. The unsatisfactory nature of the results was probably due to interference effects unavoidable with a continuous-wave technique in which the plates tested were only a few wavelengths in thickness. A transmission method employing pulsed vibrations would probably avoid some of the above difficulties and could ultimately prove successful. The adoption of transmission methods, however, would involve formidable engineering problems since it is necessary to move probes over both sides of the plate while keeping them diametrically opposite.

MULTIPLE-ECHO TECHNIQUE

Another method recommended for the testing of thin plates which avoids the necessity for having the probes on both sides of the plate is the multiple-echo technique. A single probe is used and the transmitted pulse and its reflections are indicated as

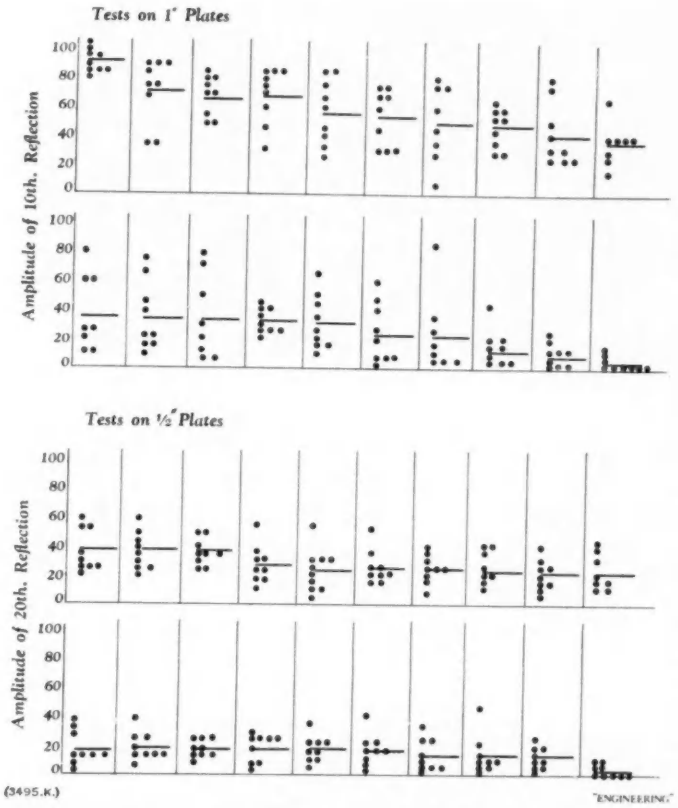


Fig. 10 Echo tests on 1 in. and ½ in. plates. Each column shows the variation in echo amplitude observed in a single plate.

deflections of the trace on an oscillograph screen. By using a suitable time scale it is possible to show the intensity of the successive echoes of the pulse as it is reflected backwards and forwards across the plate a considerable number of times. The presence of a lamination alters the time interval between the reflected pulses and so changes the pattern on the oscillograph screen. Also, since the pulse is reflected about twice as frequently if a lamination is present, and since it is likely that part of the ultrasonic energy will be dissipated at the lamination, the intensity of the multiple reflection is reduced. This is illustrated diagrammatically in Fig. 8. This method can be employed even when the plate thickness is such that the returned echo arrives at the probe while the pulse is still being transmitted. Automatic monitoring may be carried out using the same type of electronic device as previously mentioned. In this case, however, the monitor is not used to indicate the reception of flaw echoes, but indicates the presence of a lamination by a reduction in the amplitude of the pulse. A relay is caused to operate whenever the intensity of the echoes returning to the surface after a given time interval decreases below a predetermined value.

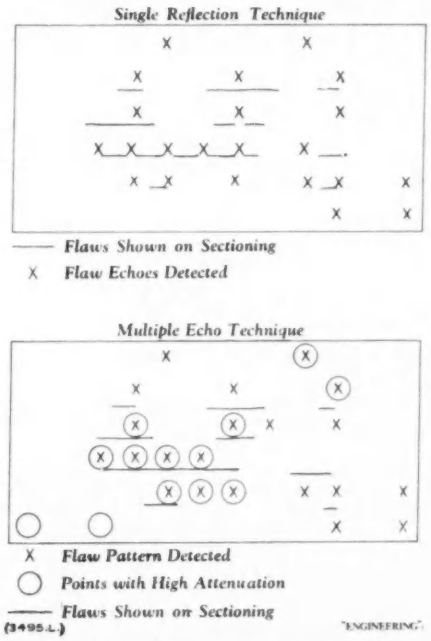


Fig. 11 Comparison of test results with subsequent metallographic examination.

In order to determine whether this method might be suitable for testing plates on a production scale a considerable number of 1 in., ½ in. and ¾ in. thick plates were examined. By visual examination of the oscillograph trace it was possible to detect laminations with reasonable certainty. Attempts to apply the automatic monitor, however, did not prove successful, since it was found that, under normal test conditions, the apparent absorption characteristics of the plates varied widely both from one plate to another and also from one position to another within the same plate. Fig. 9 shows traces obtained at three positions within one ¾ in. mild-steel plate. Trace (*b*) shows the presence of a flaw, but the attenuation of the pulse is intermediate between that of the two sound regions characterised by the traces (*a*) and (*c*). Thus, although the flaw can be detected by visual observation of the oscillograph trace it could not be shown by use of the automatic monitor. Fig. 10 shows the extent of the variation in intensity of the ultrasonic pulse reflections, at a constant instrument sensitivity, for 20 1 in. and ½ in. plates. The readings represent the amplitude of the echoes received on the oscillograph after ten reflections in the case of 1 in. plates and twenty reflections in the case of the ½ in. plates, each column indicating the variation in echo amplitude within a single plate; the horizontal line in each column indicates the mean value of the amplitude. Examination of the form of trace confirmed that in no case was a lamination present, but the variation in trace height was so great that no suitable setting of the automatic control could be obtained.

It was anticipated that some of the variation in attenuation of the pulse might be attributable to variation in surface contact, but while this factor had a significant effect in a few cases, in others it was possible to show that similar traces were obtained after the plate surfaces had been ground to a smooth finish. Local areas showing high and low attenuation were sectioned and examined metallographically in an attempt to account for the variation in results, and in some cases the increased attenuation could be attributed to the presence of minor non-metallic inclusions. In many instances, however, there was no macro or microscopic feature which could be related to the attenuation.

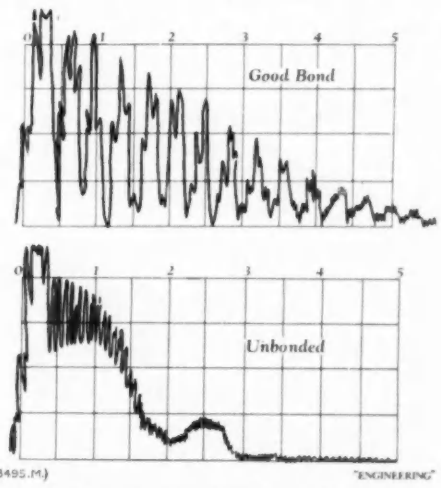


Fig. 12 Oscillograms obtained on 0·3 in. thick stainless-steel clad plate, using the multiple-echo technique.

Fig. 11 shows the results of tests on a plate using both the multiple echo and single reflection techniques. Very similar indications were obtained by visual observation of the oscillograph trace with the two methods, and there was good agreement between flaw indications and defects which were found on sectioning. These results, however, also show the unreliability of attenuation as a criterion.

One application for which the multiple-echo technique shows promise is the detection of unbonded areas in clad plates (for example, a mild-steel plate with a veneer of stainless steel on one surface). In this case any defect is very near the clad surface so that unbonded areas are indicated by very frequent reflections of the ultrasonic pulse accompanied by a marked increase in attenuation which can usually be indicated by the control device. The type of traces obtained when testing a 0·3 in. thick plate with 20 per cent. cladding are shown in Fig. 12.

On the basis of the above experiments it would appear that methods of automatic flaw indication based on the diminution of a transmitted or reflected ultrasonic beam are not very satisfactory for the testing of steel plate on a production scale. For plates below about 1 in. thickness, it is considered that a suitably modified direct-reflection technique, employing separate transmitting and receiving wedge probes and automatic scanning of the oscillograph trace, is capable of giving a more positive indication of defects. This method is still open to the objection that the magnitude of the flaw echo is affected by variation in contact between the probes and the plate. In the case of visual examination it has been pointed out that this difficulty can be overcome by comparing the relative heights of the flaw and bottom echoes. Utilising this principle, equipment is in the course of development in which the amplification of the received signal is automatically compensated so that the intensity of the bottom echo remains constant. This makes it possible to preset the equipment to indicate any defects giving a flaw echo above a chosen intensity, irrespective of transmission variables. If the not inconsiderable problems of applying the above technique can be successfully overcome, it would seem possible to use ultrasonic testing of plates on a large scale at a rapid rate.

CONCLUSION

It will be appreciated from the foregoing discussion that there are many testing problems in the heavy steel industry which might be solved by application of ultrasonics and that there is an equal diversity of methods of testing and testing equipment. No single equipment can be sufficiently adaptable to make it suitable for testing all forms of product and it should be realised that the successful application of ultrasonic tests depends on the development of suitable techniques for specific inspection problems. An attempt has been made to indicate the forms of testing which are most likely to prove successful in certain applications and to point out the dangers of misapplication of certain techniques. It is hoped that the information which has been given regarding the practical difficulties in the application and interpretation of tests, may be of interest to designers of equipment, metallurgists and consumers in their co-operative endeavours to further the development of ultrasonic testing.

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DOUBLING TELEPHONE CAPACITY

The provision of an additional telephone circuit on an existing overhead line is possible with the single-channel carrier equipment manufactured by Pye Telecommunications, Limited, Cambridge, Cambridgeshire. Two types, PTC 1004 and 1005, are produced—the former for battery operation, the latter for mains. The carrier frequency is 54 kc/s in one direction and 85 kc/s in the other. The transmitter consists of a simple amplitude-modulated oscillator, and the receiver incorporates a diode detector followed by an amplifier. The calling-signal receiver is basically a germanium diode operating a sensitive relay, the contacts of which can be used to operate calling or alarm circuits.

To connect the apparatus to the aerial line it is only necessary to loop the existing audio channel through the carrier units at each end. The unit is designed to operate with magneto, CBS or CB exchanges.

SIMPLIFIED CONTROLLER FOR OIL-FIRED BOILERS

An automatic control, for small and medium oil-fired boilers of up to 80,000 lb. per hour steaming capacity, which has been designed to a price fixed by the demand of the users, has been put on the market by James Gordon and Company, Limited, Dalston-gardens, Stanmore, Middlesex. It will maintain the required proportion of oil to combustion air against a large fluctuation in steam load. The apparatus, known as the S/D control, can be adjusted so that its full sensitivity is related to the largest anticipated fluctuation in load.

One of the main advantages of the control is that it comprises only two simple units, only one of which may require outside power for actuation. Simplicity is the keynote of the design so that it is an easy matter for a mechanic to keep the units in good working order. Should manual control be temporarily required, it is possible to circumvent the control without disconnecting any of the pipes or connecting links. The layout of the control is shown in the diagram and the two principal units in the reproduced photograph.

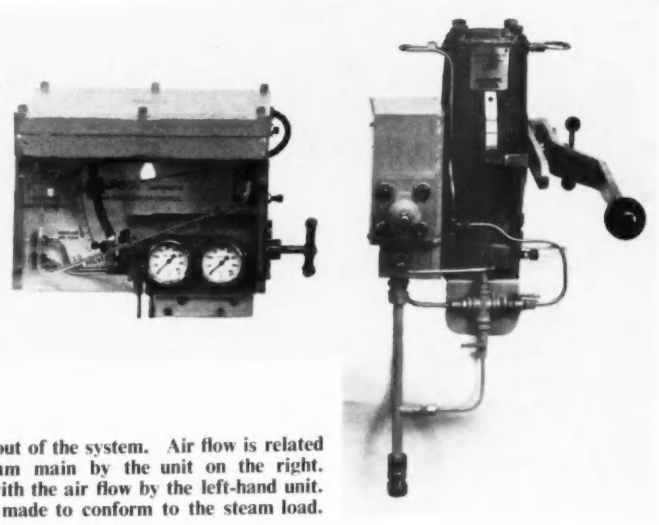
The two principal units are the air-flow controller and the air/fuel ratio controller. An alteration that occurs in the steam load, as indicated by a variation of the pressure in the steam main, is transmitted to the steam-pressure controller by a non-flow branch tapping. The steam pressure in the tapping acts against one side of a diaphragm which is sensitive to changes of the order of only a few ounces per square inch. Movement of the bellows actuates a lever system which, in turn, operates a valve controlling the flow in an external hydraulic circuit (compressed air, water or oil under pressure) to one side or other of a piston in a power cylinder. Any resultant movement of the piston is transmitted by a bell crank and linkage to the damper in the main air duct. Thus any change in the steam pressure is immediately reflected by a modification of the flow of combustion air to the burners.

The movement of this same linkage also rotates a cam, so moving a spring-loaded follower which, working back through the lever system, causes a restoring load to be fed back to the bellows. The flow in the external hydraulic system to the power cylinder is thus cut off and a condition of equilibrium reached. The cam profile may be cut so that an approximately linear relationship obtains between the piston position (corresponding to the steam load) and the effective orientation of the damper (corresponding to the air flow) thereby avoiding the non-linear characteristic otherwise inherent in the butterfly valve. It is by changing the proportions of the lever system, involving only the shifting of a connecting link, that the sensitivity of the controller is modified.

The second unit, the air/fuel ratio controller, effects changes in the rate of oil supply to the burners to correspond with the net flow of air to the burners. The drop in air pressure across the burners is used as a measure of the air flow; tappings from the windbox and combustion chamber to the two sides of a diaphragm in the controller allow the pressure drop to be used to locate a diaphragm which, in turn, is attached through a spring-loaded lever system to pilot valves and the valve governing the pressure of oil to the burners. Thus a change in air flow is reflected by a corresponding alteration in oil flow without regard to the number of burners in operation. Adjustment of the proportions of lever system allows a predetermined air/oil ratio to be maintained so that efficient combustion prevails.

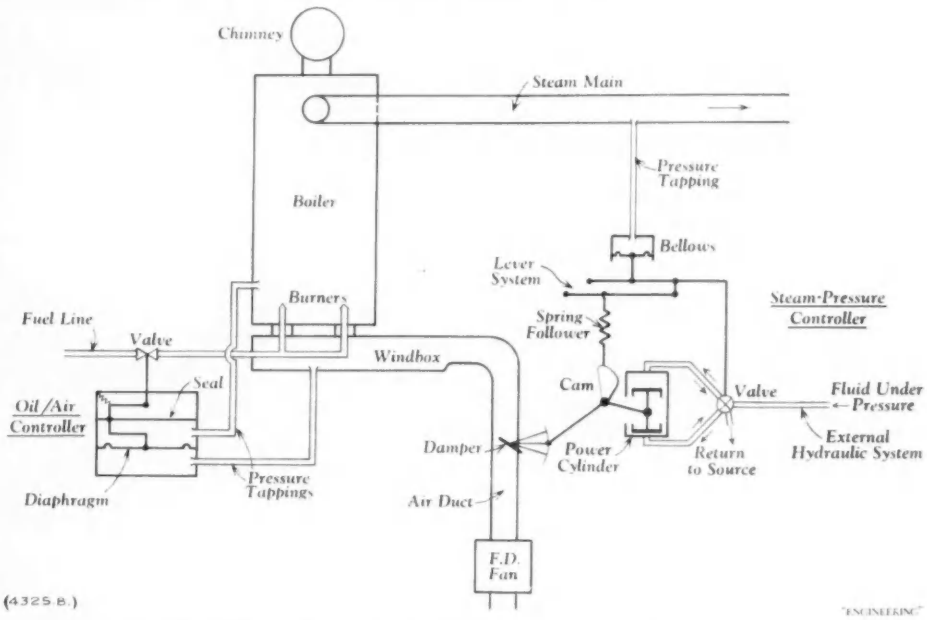
The air/oil controller can be located in any convenient position with respect to the fuel line, as long as the oil supply passes through the valve of the controller. Although the steam controller has been described as actuating a damper in the air duct, and the diagram shows this same arrangement, the air flow can also be regulated by speed regulation of the forced-draught fan. In addition, a draught controller can also be embodied in the system, the chimney suction being altered by adjusting the chimney damper according to the demand on the boiler. In the interests of economy there are advantages in using the fuel oil for the external medium in the power cylinder the air-flow controller; in this case, the oil, which is under pressure, is bled off from the supply.

This equipment has been designed particularly with a view to use at sea and may be used for pressure or return type burners at pressures of up to 1,000 lb. per sq. in. and for forced or induced-draught installations. The boiler may be either a single or multi-burner unit and, in the latter case, burners can be inserted or withdrawn while operating under control. The boiler steam, fuel oil and air pressures as well as the boiler load are all indicated on the equipment so no further instrumentation is necessary for efficient operation.



(Right) The components of the Gordon S/D controller for small and medium-sized oil-fired boilers. On the left is the air/oil controller and on the right the air-flow controller. The complete unit was designed to a price appropriate to the small-boiler user and for easy maintenance.

(Below) Diagrammatic layout of the system. Air flow is related to the pressure in the steam main by the unit on the right. The oil flow is kept in step with the air flow by the left-hand unit. Fuel consumption is thereby made to conform to the steam load.



Institution of Naval Architects Spring Meeting (*concluded from page* 625, *May* 17)

CRACKS IN SHIPS' PLATES

At the closing session, on the afternoon of March 28, of the Spring Meeting of the Institution of Naval Architects, two papers were presented. The first of these, by Mr. G. M. Boyd, of Lloyd's, Register of Shipping, dealt with " The Conditions for Unstable Rupturing of a Wide Plate," the term " unstable rupturing " being defined as " the condition under which a fracture will extend under the sole influence of the elastic energy stored in the structure, without increase in the external load."

Though much study had been devoted to " fracture mechanics," Mr. Boyd said, there was still no wholly satisfactory theory for the brittle rupture of mild steel. His paper reviewed the present state of knowledge of the subject and suggested various ways in which the available theories might be extended, " at least qualitatively." After surveying the researches of various investigators—Dr. C. F. Tipper, A. A. Griffith, G. R. Irwin, Dr. A. A. Wells, N. F. Mott, and Dr. T. S. Robertson,—and collating their conclusions, he summarised the position in the general statement that an unstable (brittle) fracture could not commence unless a certain " initiation energy " was supplied from an external source; and that the energy needed for that purpose might be reduced by increasing the stress, lowering the temperature, or introducing a notch. Dr. Tipper had introduced a notched tensile test in her experiments on brittle fracture and had found that there was a " transition tempera-

ture " above which the fractures were mainly fibrous and below which they were mainly brittle. In Dr. T. S. Robertson's test, a temperature gradient was provided through the specimen, with the temperature increasing with the distance inward from the notch. With the specimen under tension, a fracture was initiated by impact and allowed to extend until it stopped. The temperature at that point was called the " arrest temperature " for the particular tensile stress. Correlating the Tipper and Robertson tests, Mr. Boyd suggested that the Tipper transition temperature should be identical with the limiting arrest temperature of Robertson; and that the best safeguard against fracturing, in the case of ships, was to ensure that, for the material used, the characteristic minimum value for the work done against the resistance of the material in extending a crack (i.e., its toughness) was greater, at all operating temperatures, than the corresponding maximum value for the elastic energy released per unit extension of the crack. Those values could be determined by the Tipper or Robertson tests, and probably by others also.

PREVENTIVE MEASURES

Dr. A. A. Wells, opening the discusion, questioned Mr. Boyd's assumption that there was or should be a steady state, with definite properties. In particular, he disagreed with the suggestion that the value of the strain energy released became steady when the crack reached its uniform terminal velocity. He asked Mr. Boyd to define a little more closely, if possible, the conditions of cracking to which he referred. If the crack was very large in comparison with the plate containing it, its postulated condition might be representative; but, if, as Dr. Wells believed it should be, the crack was one running out in a steel plate and still unaffected by the edge conditions, he thought that a dimensional analysis would show that the supposed steady state could not exist, and that the value of the strain energy release rate must continue to rise. In terms of experimental evidence there was nothing either way that could be adduced to prove the point; experiments had not been done on a sufficiently large scale. With regard to the further analysis of the interactions of release of strain energy and absorption of work, he was in reasonable agreement. The fact that he had criticised the assumption illustrated the point that there was, as yet, no wholly satisfactory quantitative theory.

Mr. J. M. Murray, M.B.E., thought that the paper, while speculative, gave a convincing explanation of the mechanism of the propagation of brittle cracks. It appeared to him, in considering the effect of an initial notch, that the initial value of the surface energy must be more or less independent of the length of the notch. If that was so, it would follow that the length of the notch was not the preponderating factor in the initiation of brittle fracture. Something had been done in recent years to improve the toughness of ship steel, and it was hoped that the small fracture which extended for a few inches would not be so common as it had been in the past. The whole problem seemed to demand two approaches: the elimination as far as possible of the initial notch, and a further increase in the toughness of the material.

Dr. W. D. Biggs said that the condition for fracture initiation had been shown to be associated with the application of stresses which created simulations of dislocation at certain borders within the crystal. In America, it had been shown that hard particles of macrostructure constituents could act in much the same way. It was to be expected that the initiation energy required by a hypothesis such as Mr. Boyd's would be strongly affected by such factors as grain size, the relative strengths of the grain and the grain boundary, and the type, hardness, and distribution of the macro constituent. Dr. Biggs felt that a similar argument could be applied to the question of the propagation of a fracture. The large amount of work involved in the propagation of an initial crack was too often ignored. It seemed to him, however, that the formulation of a purely quantitative hypothesis must take into account, more specifically than was usually the case, the metallurgical features of the material.

Dr. R. Weck said that it was evident from Dr. Biggs's contribution that the approach of the metallurgist to the subject was quite different from that of the engineer. Mr. Boyd's paper was the quintessence of the engineer's approach: an extremely plastic picture of fracture mechanics understandable or imparting itself understandably to an ordinary engineer. Metallurgists tended to consider that type of approach as being rather crude, but he wondered whether they were not doing engineers an injustice. Metallurgists connected with the steel industry declared that it was impossible under present conditions to produce steel of better notch toughness at lower temperatures, so the engineer was faced with the problem of having to use what he was given. He could solve the problem only by trying to understand, not the metallurgy of it, but the mechanics; because he could only apply mechanical means by change in design or in fabrication methods.

Mr. G. Coats, speaking as a physicist, was interested to hear the discussion on the temperature dependence attributed to the toughness characteristic, which he considered to be an extremely important item for future research; but, he pointed out, it was not really known whether it depended on temperature in the way that it appeared to do. Dr. Weck tended to the view that what was really measured was the width of the band and the band formation; but there was still a temperature dependence in steel.

A REMARKABLE FRACTURE

Professor A. M. Robb, referring to the section of the paper on " Applications to Ship Fractures," described what he thought must be one of the most remarkable ship fractures, 30 to 38 ft. long, round the bottom, round the bilge and up the side. The ship, an American one, had made a trip to the Philippines and back to the west coast of America, and was then on her second journey. The shortness of her life ruled out any question of fatigue. She was rolling heavily, but there was no sign of any pitching, which ruled out any hogging or sagging conditions; also she was unlikely to have been in very high stress.

During one night there was an " explosion "; he used that word deliberately, because the gun crews turned out, thinking they were attacked. After an hour or two, they decided that there was not an attack, after all. In the morning, somebody noticed oil fuel spilling out of No. 2 oil ventilator; the hold contained water and fuel oil from the double-bottom tank below. The " explosion " was a clear indication that the crack spread very rapidly. There was no indication of a notch, but there might have been something wrong at some of the welded connections. On the strake just above the bilge, the crack ran parallel with a big weld, and about 2 in. from it; that was the nearest approach of the crack to any weld. Why did the crack stop, at both ends, three-quarters of the way across a plate? He could not understand why it went off with a bang and stopped there. Another anomaly was that the cracks in the double bottom formed a big Y, with two cracks of the Y straddling another crack, and stopping part of the way across a plate. The final anomaly, for which there did not seem to be any reason, was that on the bottom, half way across, the outer edge of one plate was dead in line with the inner edge of another. It suggested that there was some tendency to deformation.

Dr. W. D. Biggs, intervening in reply to the remarks of Dr. Weck, said that he was not condemning the approach to brittle fracture via fracture mechanics as both the mechanical and the metallurgical ideas must come together before the problem could be solved satisfactorily. The steelmakers could provide the right sort of material, but at present it was economically difficult to do so. They were restricted to some extent because the engineer laid down certain requirements. The conditions probably associated with dislocation were affected by carbon, and the engineer required carbon in the steel. The steelmakers knew empirically that increase of manganese content would produce a steel possessing notch toughness, but the engineer wanted to weld plates together; so cracks occurred alongside welds. There must be some agreement between what the engineer required and what the metallurgist required, apart from economics; in one classic case, some 5 per cent. nickel steel was built into two storage tanks, with spectacular and rather disastrous consequences.

Mr. Boyd, replying to the discussion, was not disturbed by the fact that Dr. Wells and he disagreed about parts of the paper; anyone who looked at the subject dispassionately would say that at least half the people engaged on that sort of work were wrong. Both Mr. Murray and Mr. Coats held that the depth of the notch was not an important factor; but he thought that it must be. Professor Robb had referred to another set of anomalies. Lloyd's Register had hundreds of records, and each one contained completely baffling features.

HULL PRESSURES

The final paper, by Dr. N. Hogben, on the subject of " Ship Hull Pressure Measurements," described a series of experiments carried out at King's College, Newcastle-upon-Tyne, to measure the pressures normal to the hull of a 100 in. model while it was being towed. The pressures were measured by means of open-topped water manometers at 76 positions (71 on the port side and 5 on the starboard) and at nine speeds in the range $\frac{V}{\sqrt{L}} = 0{\cdot}8$ to $1{\cdot}1$. Wave profiles were obtained photographically to assist in extrapolating the pressure measurements up to the free surface. The manometer bank was fitted with a cut-off valve, opened and closed by a solenoid, and so designed that its operation did not affect the volume of water in the circuit. The use of the valve enabled readings of the levels in the manometer tubes to be taken between runs by means of a micrometer depth gauge. It was found that an accuracy of $\pm 0{\cdot}005$ in. could be consistently maintained. The holes in the wax hull of the model were $\frac{1}{16}$ in. at the surface, and the internal tubing, of P.V.C. plastic, was of $\frac{1}{8}$ in. bore. The holes were arranged in five layers on the port side and were so positioned as to form a regular grid when marked on the body sections. The five holes on the starboard side were placed there as a check, to show whether readings were affected by local disturbances such as might arise from small irregularities in the wax surface. No trip wire was fitted.

Mr. W. C. S. Wigley said that various methods had been proposed for correcting the wave resistance, as calculated, by making allowance for the peculiarity of oscillation at low speeds. Generally, it had been assumed that oscillation at those speeds would occur in a perfect fluid, but actually it did not occur because of viscosity. There were two views about the matter however; his own was that the oscillation was probably a perfect fluid effect and that it was cancelled by the viscosity.

Mr. Wigley then read a translation that he had made of a communication he had received from Dr. R. S. Guilloton.

Dr. Guilloton suggested that Dr. Hogben might have found room for a critical examination of some important work of the same type by Captain H. F. Eggert, which appeared in two papers read before the Society of Naval Architects and Marine Engineers in New York, the first in 1935; such an examination would serve to underline the novelties in the present paper, and the developments which might be expected from them. In fact, the resistance to motion calculated from the pressures measured by Eggert was, at low speeds, higher than the residuary resistance evaluated by the usual methods; Dr. Hogben obtained a contrary result. The author remarked that the results of the wave calculations differed

from the resistances derived from the integration of pressures; but such calculations would be useless until a practical method of correction was published, to include the terms of orders above the first. The author gave wave profiles extrapolated from pressures; how were these waves obtained?

One point, Dr. Guilloton continued, seemed to him to be fundamental: the hull was moving through a fluid without viscosity, subject to Froude's law of similarity. Experiment showed that that assumption was right, and that there was, in fact, a part of the resistance of ships which followed approximately the law of similarity excluding the viscosity. That could be explained by the fact that, in the operation of a ship, the water could be considered as a perfect fluid, except for a small volume in the immediate neighbourhood of the hull. It followed that, in speaking of resistance normal to the hull, or of wave resistance, or even of residuary resistance, it was resistance in a fluid without viscosity which was meant, apart from certain refinements. It seemed risky, therefore, to determine that resistance as the author had done by measurements made on the hull, i.e., precisely in that small volume of fluid which was not perfect.

In 1952, in a paper to the I.N.A., Dr. Guilloton recalled, he had proposed the surface wave as a basis for that calculation; it had the advantage of being the resultant of motions existing in the whole of that part of the fluid which could be considered as without viscosity, and is directly controlled by the boundary condition at the free surface which gave rise to Froude's law of similarity. It did not seem that there was any more theoretical complication in passing from the surface wave to the resistance than in passing from Dr. Hogben's manometric heights to the resistance, for it seemed that the theory of the Pitot tube was neither simple nor certain.

SURFACE WAVE EFFECTS

Mr. H. Lackenby said that the British Shipbuilding Research Association, in conjunction with the National Physical Laboratory, had been engaged on somewhat similar work to that of Dr. Hogben for a considerable time. It had been concerned with the interdependence of wavemaking and skin friction resistance, but the aspect had been broadened to cover the physical nature of resistance in general. He suggested that Dr. Hogben had left something out, in that, when measuring the pressure on the model, he had not separated out the wavemaking resistance. The measured resistance included resistance of viscous origin; in other words, the resistances of viscous origin and of gravitational origin had not been completely separated.

In the B.S.R.A. and N.P.L. work, the total head and wake traverse were included, in addition to the pressure plotting which Dr. Hogben had done; thus would we obtain all the components of resistance.

Professor A. M. Robb congratulated Dr. Hogben on his clear statement of the fundamental problems, the separation of pressure forces and friction forces. He said: "Experimentally a simple and unequivocal definition is to name the forces normal to the hull surface, pressure forces, and the forces tangential to the surface, friction forces. It is possible to separate these two forces on the basis of this definition by direct measurement." Professor Robb felt that, instead of referring to pressure resistance, it would be justifiable to refer to wavemaking resistance: the waves were the visible manifestation on the surfaces of the distribution of pressure.

Dr. Hogben, while stating that he would reply to most of the discussion in writing, mentioned that some work he had been doing since leaving Newcastle was directed towards the influence of viscosity. The approach was to try to assess the effective thickness of the boundary layer due to pressure and viscosity. He hoped that, when that work was complete, it would throw some light on the very important question of viscosity.

BRITISH WATERWHEEL GENERATORS IN NORWAY

High-Head Station for Aluminium Manufacture

The equipment of the Aura power station at Sunndalsfjord on the west coast of Norway, near Kristiansund, has now been completed after a long delay which was partly caused by the German occupation of the country. It is operated by Norges Vassdrags og Elektrisitetsvesen and is used to supply aluminium works at Sunndalsrora nearby and the counties of Møre, Romsdal and Trøndelag. The plant is mainly of British origin and consists of two 62·5 MVA and four 37·5 MVA generators, which were manufactured by Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17. There is also another 62·5 MVA set, the alternator for which was supplied by the General Electric Company, Limited, Kingsway, London, W.C.2.

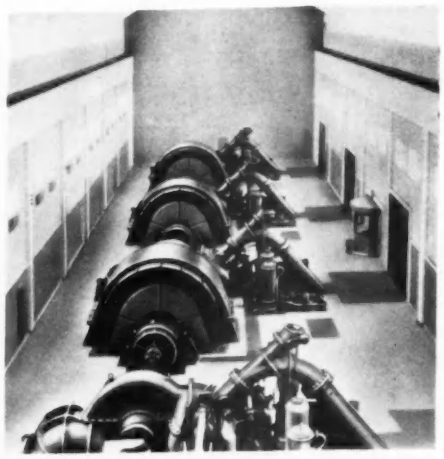


Fig. 1 View in the underground power station at Aura, Norway, showing four 37·5 MVA Metropolitan-Vickers waterwheel generators.

The station obtains water from a catchment area of 330 square miles in which a number of lakes have been dammed and regulated. The last of these lakes is connected by a tunnel some 10 miles long to the hill above the power station, there being a net drop of 2,250 ft. to the latter from the valve chamber. The station itself, an interior view of which is shown in Fig. 1, consists of two large halls which were blasted out of the rock and to which access is obtained by two tunnels each 300 yards long.

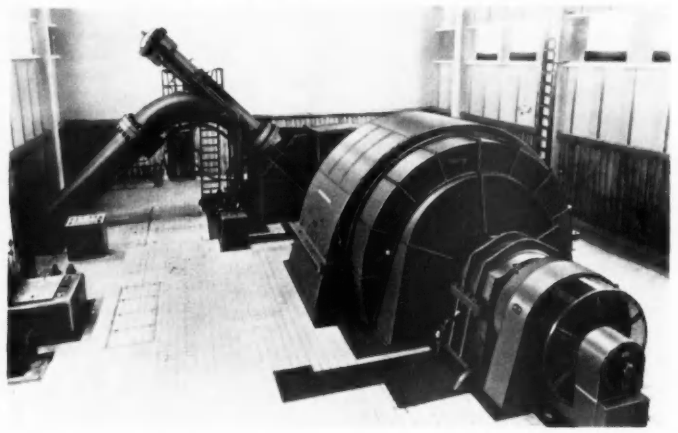


Fig. 2 One of the 62·5 MVA hydro-electric sets in the Aura station.

The two 62·5 MVA Metropolitan-Vickers sets are designed to run at 428·6 r.p.m. and to generate three-phase current at 12·3 kV ± 5 per cent. The four 37·5 MVA machines run at 500 r.p.m. and generate three-phase current at 12 kV ± 7·5 per cent. The frequency in both cases is 50 cycles.

As will be seen from Fig. 2, which shows one of the 62·5 MVA machines, all the sets are of the enclosed and self-ventilated type and are driven by Pelton turbines. Ventilation is provided by axial-flow propeller fans which are mounted at each end of the rotor, the air being passed over two pairs of water-cooled units mounted in the foundations.

The stator frame is built up from welded steel plates and is split horizontally to facilitate transport and erection. The core consists of steel laminations and the winding is symmetrical and star-connected. The rotor body is of the solid type and is built up from rolled steel discs, which are spigoted and bolted together by axial bolts. There is no through shaft and the shaft ends are secured by steel bolts passing through the body. The poles consist of laminations which are attached to the body by T-shaped projections. These projections fit into slots in the rotor and are finally secured by tapered keys. The field windings of the 37·5 MVA machines consist of bare copper strap, wound on edge. On each of the 62·5 MVA sets they are of the square-ended type and are built up of flat copper strips, which are dovetailed and silver soldered together at the corners. All the sets have a permanent magnet generator from which current is supplied to the governor pendulum motor.

The bearings of the 37·5 MVA generators are cooled by passing water through copper spirals embedded in the bearing metal. The 62·5 MVA machines each have bearings of the spherically seated type and are provided with oil rings, which are supplied from an external lubricating system. Both sets of generators are equipped with two bearings, which have been designed to withstand all the radial loads from the turbines.

Each machine is provided with main and auxiliary exciters, the larger sets being designed for a runaway speed of 780 r.p.m. and a flywheel effort of 700 tons/metre square. The corresponding figures for the smaller set are 900 r.p.m. and 350 tons/metre square.

Warning devices in the form of alarm thermometers are placed in the bearings and in the cold and warm air ducts. Each machine has also an overspeed relay and thermocouples for remotely measuring the temperature at specified points.

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AIR CONDITIONING LECTURES

A course of 24 lectures on air conditioning has been arranged by the National College for Heating, Ventilating, Refrigeration and Fan Engineering, Borough Polytechnic, Borough-road, London, S.E.1. They commence on Wednesday, October 2, and will continue on each succeeding Wednesday. They are intended to give a general picture of design and use of air-conditioning plant, and participants should have some engineering knowledge. The enrolment fee is £5 5*s*. and forms can be obtained from the clerk to the governors. As there will be no laboratory work, students are recommended to attend a separate course on Measurement techniques to be held on Mondays.

Book Reviews

METAL BEHAVIOUR

Alloy Series in Physical Metallurgy *and* **Principles of Physical Metallurgy.** By MORTON C. SMITH. *Constable and Company, Limited,* 10 *Orange-street, London, W.C.*2. (50*s.* each volume.)

These two publications really form a single treatise of 730 pages, divided into two slim volumes. The author's aim is " to develop and to present a science of metal behaviour as an integrated, consistent and satisfying chain of reasoning, extending from the familiar principles of physics and chemistry to the observed behaviour of the industrial metal and their alloys." Even if not completely successful it is nevertheless a brave attempt. Information gathered from many sources—generously acknowledged—is skilfully woven into this account of metallic behaviour and its underlying causes.

The " Principles " starts with the structure of the atom, and its resultant physical and chemical behaviour. Then follow crystallography in general, atomic bonding, metallic crystals and polymorphism. Next, a long chapter, under the umbrella title of " Crystal Imperfections," links together in an unusual way many aspects such as the freezing of a pure metal, spheroidisation, defect lattices, dislocations, interstitial compounds, solid solutions and order-disorder changes. A short section on electrical and magnetic properties fits neatly into place here. A detailed account is given of plastic deformation, and the effects of subsequent treatment at elevated temperatures. The closing chapter covers fracture, including fatigue failure which is sensibly handled. The volume on " Alloy Series " is launched on the phase rule, followed by constitutional diagrams and types of alloy, with a brief statement of changes in the solid state. On this foundation is based a detailed treatment of steels and of cast irons, these together occupying nearly half the book. The final chapter, brief but adequate, refers to ternary and higher systems.

A reader of these two volumes will be impressed by the loving care with which the text is assembled. The work conforms to a recognisable pattern and has a continuous thread running through it —that of the author's own journey through the maze of ever-increasing metallurgical data, seeking his " satisfying chain of reasoning." The stages in this journey, however, may not suit all readers: the presentation is not uniform in depth and the order is often questionable. For example, a student who has soundly grasped the phase rule hardly needs in the next chapter an elaborate 12-page treatment, with five consecutive versions of the constitution diagram, in order to establish the zinc-tin system. Again, the chapter on " changes in the solid state " does not include precipitation-hardening, since its detailed treatment has already been given in an earlier chapter, where it is out of place. The author expresses qualms lest his presentation calls forth criticism from " the real scientist . . ., the down-to-earth engineer . . ., and the teacher," and one must admit that grounds for such criticism do exist.

The teacher of metallurgy will hardly approve the author's practice of implying general principles from an individual case, instead of establishing general foundations first: this applies especially in his handling of eutectics and of eutectoids. Nor is discussion of the latter adequate for, although he deals with steels in detail, he fails to provide a general framework of eutectoid reactions into which the specific case of carbon steels can be fitted. Incompleteness and lack of balance are thus inevitable and are emphasised by the undue length of this chapter and the surprising inclusion of a chapter entirely on cast irons, with no corresponding chapter on any of the non-ferrous materials.

The author's originality of approach is sometimes stimulating but has also led to unfortunate departures from accepted practice, as with the unorthodox classification of energy levels in the opening chapter. Here, too, his treatment of the properties of electrons is not satisfactory. The cumbersome 6-page version of the periodic table in this chapter would be better placed as a fold-in at the back of the book, leaving in the text a simplified one-page table.

The work of Hume-Rothery receives two mentions (one of which, on page 98, is omitted from the index). This section is not well set out, however, and the reference given has long been superseded. In dealing with substitutional solid solutions and atomic diameters, a serious omission in a book of this kind is a list of the common metals and their values.

Proof correction is of a high standard and typographical errors are rare; but Fig. 9.1 is not square; Fig. 9.4 is not clear enough to be convincing; the top line of page 367 is misplaced; and Fig. 3.12 (Alloy Series) is incomplete. Quality of print is good and the black cloth covers are serviceable. The author has taken the trouble to add to each volume that most valuable adjunct, a detailed index. Despite his claim to conciseness the style is verbose, in places even laboured; an example is unnecessarily heavy treatment of the Lever Law (page 36, Alloy Series). Had all unwanted words and repetitions been deleted throughout, at least 20 per cent. could have been saved in length. On a less heavily loaded paper this treatise could then readily have been produced as a single volume little more than an inch thick, with a considerable reduction in the present high price of £5. Such a change of paper would also aid legibility, which compares unfavourably with that of similar books.

The author's English is good. His few inevitable Americanisms are quite acceptable. It is unfortunate, however, that temperatures throughout are quoted on only the Fahrenheit scale (even on numerous diagrams where no units at all are stated !). In a modern scientific work the omission of the Centigrade scale for comparison is an almost unpardonable lapse, especially if intended for the British market.

Despite its many drawbacks, Morton Smith's treatise has a genuine smack about it which could justify a second edition if improved. Many practical metallurgists might find such a book of value, even though it is not considered suitable as a textbook for formal instruction.

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PIPPARD AND BAKER REVISED

The Analysis of Engineering Structures. By A. J. S. PIPPARD and J. F. BAKER. *Edward Arnold (Publishers), Limited,* 41 *Maddox-street, London, W.*1. (60*s.*)

This is the third edition of a well-known and much used book that was first published in 1936. It should find a place among the books of all final degree students and practising structural engineers. There is a wealth of material but it is permissible to wonder whether such a compilation would have arisen if a similar book had been planned now instead of modifying an existing text.

The first portion of the book consists of the formal presentation of the classical elastic theory of framed structures up to the stage when moment distribution was a modern technique. The treatment is sound, though open to criticism on points of detail; for example, moment-area methods are hardly touched on and your reviewer has never liked the proof given of Castigliano's second theorem. As the preface says, this portion of the book has been hardly altered, which is a pity since there have been considerable advances since the 1930's and, moreover, the connection between the theory and the behaviour of real structures is hardly brought to the notice of the student. Contrasting with this idealised theory of structures, the exposition of reinforced concrete is a presentation of rationalised empirical design rules and is thus on a different logical basis.

The remaining chapters reflect the different specialised interests of the authors. The chapter on Voussoir arches is included as part of the work on failure tests but that on the bow girder remains on a theoretical basis. The section on the design of steel-framed buildings has been reduced to an amount more appropriate to a general textbook. The short chapter on slabs has been removed and thus, in a book the title of which refers to structures in general, there is now no mention of slabs, shells, or composite action. The chapter on earth-retaining structures has been ably re-written by Dr. A. W. Bishop but the arbitrariness of the selection of material is again apparent: the stability of foundations is probably of even more importance to structural engineers than retaining walls but it is not dealt with.

Considering its parentage perhaps the most surprising feature of the new edition is the perfunctory relegation of plasticity to a short last chapter. A newly conceived text would surely harness the twin theories of elasticity and plasticity in tandem at an early stage in the development of the subject.

This review seems critical but there is much meat to hack at and there is good reason to be grateful for such a gargantuan account of engineering structures. The edition should have a useful lease of life as a standard text but it is hoped that the process of assimilation and digestion of modern work will produce in the not too distant future a new equivalent of the 1936 edition of Pippard and Baker.

* * *

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Plugs and Sockets. THE PLESSEY COMPANY LTD., winding and connection division, Kembrey-street, Swindon, Wilts. Details are given of the design and electrical charactristics of Plessey Mark 4 aluminium plugs and sockets, manufactured in accordance with the conditions specified in R.C.S. 321. Indication is given of the correct outlet fittings for every type of cable in normal use. Illustrated brochure.

Pneumatic Grinders. CONSOLIDATED PNEUMATIC TOOL CO. LTD., 232 Dawes-road, London, S.W.6. The fourth section of a new series of publications, this one deals with vane-type industrial pneumatic tools, and covers hand-held grinders of various types both wet and dry, sanders and polishers, circular saws, and wire-brushing machines, together with dust extractors and other accessories. Illustrated brochure.

Electronic Instrumentation. MARCONI INSTRUMENTS LTD., St. Albans, Herts. Comprehensive details of the range of electronic equipment manufactured is given in " Marconi Instruments 1957." In addition to instruments for radio communication, instruments for industrial equipment, such as X-ray apparatus and pH meters, are also described. Illustrated book.

Hydraulic Machinery. TANGYES, LTD., Cornwall Works, Smethwick, Birmingham. Loose-leaf catalogue, with details of hydraulic wheel presses, vertical presses for forcing and assembling, and plate-bending presses with swivel heads, to enable complete box forms to be produced.

Gear Grinding. COVENTRY GAUGE AND TOOL CO. LTD., P.O. Box 39, Fletchamstead Highway, Coventry. Details of a gear grinding service for spur and helical gears. Illustrated leaflet with details of range of sizes handled.

Power Rectifiers. BRITISH THOMSON-HOUSTON CO. LTD., Crown House, Aldwych, London. W.C.2. Germanium power rectifiers for traction purposes; their construction and associated equipment for use on trains. Illustrated leaflet No. 912104.

Hot Water Radiators. HURSEAL GROUP SALES, LTD., 229 Regent-street, London, W.1. " Gulf " radiators for space heating using hot water. Large range of types and sizes. Leaflet.

WHAT THE OTHER HALF MAKES

ENGINEERING PRODUCTS FROM THE SOVIET BLOC

Concluded from page 628, May 17

Sections on instruments, vehicles, and plant for the consumer industries conclude our survey of engineering production in East Germany. It forms part of a longer article in which products of Czechoslovakia and the Soviet Union have also been described.

3—East Germany (concluded)

Instruments and Optics

Nuclear Physics Equipment.—The Centre for Nuclear Research and Engineering of the G.D.R. demonstrated equipment from seven factories, including VEB Carl Zeiss Jena and VEB Vacutronic Dresden. Of special interest was a large actinometer which can be used for recording not only radiation density but also single impulses. The safe use of radioactive isotopes and their manipulation and transport was also illustrated. Fig. 25 shows items of equipment for nuclear research made by Carl Zeiss of Jena, while an isotope manipulating device for non-destructive workshop testing can be seen in Fig. 26. Made by the VEB Transformatoren und Röntgenwerk Dresden, it may be used when loaded with 1 curie of cobalt 60 for radiographic examination of thick-walled steel vessels, castings and similar work and for weld investigation of items where access is normally difficult. In the illustration the isotope is seen exposed. Fig. 27 shows the TuRTG2 radiation unit made at the same works and designed for deep radiation therapy. The treatment table is on rails and the projector can be rotated through 360 deg.

Optics.—Carl Zeiss Jena exhibited a wide range of optical equipment from photometers and polarimeters to astronomical apparatus and a new electron microscope. Binoculars, cameras and cine-projectors were also on display.

Gear Tooth Checking.—A precision testing instrument for micro-teeth was shown by VEB Feinmesszeugfabrik Suhl. It is designed for checking toothed wheels with involute, cycloid and special tooth profiles in the clock and watch industries. Faults are detected automatically by following the shape of teeth, without using specimen wheels or gauging racks. The instrument can be used in conjunction with a photographic recorder.

Transport and Locomotion

Aircraft.—The German Democratic Republic has been building aircraft, aircraft propulsion plants and other associated equipment for a comparatively short time, and such products were exhibited for the first time at this year's Leipzig Fair. An important item shown was the Ilyushin 14P, a Soviet passenger aeroplane made under licence in East Germany. The seating has been increased from 18 to 26. The Il 14P is powered by two 14 cylinder two-row radial engines, which are also made in the G.D.R., together with navigation, control and hydromechanical equipment. Sailplanes were also in evidence, including the one-seater Libelle (see ENGINEERING, March 15, page 324) and the two-seater FES530.

Locomotive.—Fig. 28 shows the industrial locomotive type EL3 (BoBo) made by VEB Lokomotivbau Elektrotechnische Werke Hans Baimler of Henningsdorf. Weighing 75 tons, it operates on 1·2 kV direct current with a power of 4 × 185 kW.

Tractor.—The crawler tractor KS30 " Urtrak " illustrated in Fig. 29, is powered by a four-cylinder Diesel motor with whirl-chamber action, developing 63 h.p. The cylinder bore is 175 mm. (6·89 in.) and the engine runs at 1,150 r.p.m. Made by the VEB Brandenburger Traktorenwerk, the Urtrak employs forced circulation cooling and has a 6 h.p. electrical starter. There are 4 forward gears and one reverse; the ground clearance is 280 mm. (11 in.); and the width of each track is 360 mm. (14 in.).

Motor Cars.—The influence of Western styling may be seen in the East German motor cars exhibited. The Automobilwerk Eisenach was showing, for example, its " Wartburg-Sport," illustrated in Fig. 30. Powered by a three-cylinder two-stroke engine developing 50 b.h.p., it is said to be capable of a top speed of 140 km. per hour (87 m.p.h.). The P70 coupé exhibited by Automobilwerk Zwickau and shown in Fig. 31 is a two-seater with spare seat in the rear. The coachwork is formed from " Duruplast."

Consumer-Goods Production

Packaging.—Modern packing methods were illustrated by the display of VEB Verpackungs und Schokoladen Maschinen Dresden. The bar-packing machine, type U460, packs from 120 to 150 chocolate bars and similar confectionery per minute. The wrapping of these articles comprises an inner wrapper of pergamyne or foil and an outer strip, or envelope label, glued together. The machine can be adjusted for various sizes of bar. Another machine wraps sweets at between 100 and 300 a minute in printed wax or cellophane paper. The machine is entirely enclosed to limit the harmful effects of sugar dust and employs continuous lubrication. The APM fully automatic packing plant is designed for filling and packing coffee substitutes, salts and other commodities into bags; the inner bag is made of pergamyne and the outer carton from cardboard.

Fruit Processing.—For sizing fruit and vegetables—asparagus, cherries, plums, onions, cucumbers and so on—the VEB Maschinenbau Burg have developed a universal sorting machine capable of up to 6 gradings in the sizes 8 to 56 mm. The output of this machine with asparagus, gooseberries and cherries is about 500 kg. per hour, and with plums and cucumbers up to 1,000 kg. per hour. The same firm makes a machine for stemming cherries, combing out currents, and cleaning cranberries and bilberries. Another machine stones plums at 850 kg. per hour and cherries at 800 kg. per hour, and a machine for shredding French beans has a maximum output of 550 kg. per hour.

Soap Press.—Said to be 100 per cent. accident proof, the semi-automatic pendulum power press made by VEB Maschinenfabrik Heidenau, is designed for embossing household and toilet soaps in box or squeezed forms. It is claimed that the machine is quieter than earlier models.

Meat Processing.—Equipment for butchers' shops and sausage factories is made by VEB Saxonia Fleischereimaschinenfabrik Leipzig, including a high-capacity electrical meat chopper, type ETW, suitable for mincing both meat and fish. The CAM80 is an automatic electric sausage dividing and filling machine powered by hydraulic (oil) pressure.

Domestic Goods.—A wide range of consumer products were also shown such as radio and television sets and grass-cutting machines.

Fig. 25 Apparatus for nuclear research made by VEB Carl Zeiss of Jena.

WHAT THE OTHER HALF NEEDS

The case for initiating trade with the Soviet group of countries was stated in an article published in ENGINEERING on March 15 (page 322). Since then we have endeavoured (May 3, page 564, May 17, page 626, and the present issue, this page) to create a picture of engineering production in the U.S.S.R., Czechoslovakia and East Germany in order to indicate: first, the extent to which the Communist countries can meet their own needs and so do not require imports; second, their capacity for reciprocal trading; and third, the degree to which they represent a threat as competitors in other markets. The final article in this series sums up the trading position *vis-à-vis* various members of the group and lists the expressed import requirements of East Germany. (Since there is considerable economic integration within the Soviet Bloc it is reasonable to suppose that these needs are fairly general.) The article is based on information issued by the official Leipzig Fair agency and on a report published by the Birmingham Exchange and Engineering Centre and compiled by its manager, Mr. A. J. Cox. There are no official trade relations between this country and East Germany and to some extent the Centre fulfilled the function normally exercised at overseas fairs by the Board of Trade. The Centre handled inquiries for British goods and established formal contact with the East German Foreign Chamber of Trade. Its address is Stephenson-place, Birmingham 2.

East Germany

Organisation of Trading

Trade in Eastern Germany and in fact in all other Soviet Bloc countries, is handled in a completely different way from the West. Private merchants or manufacturers' buyers as we know them do not exist; all purchases are made through Government departments. The Foreign Chamber of Trade is divided into separate organisations known as " DIA " (Deutscher Innen und Aussenhandel), each of these organisations is concerned with particular branches of industry, for example, Machine Tool Export, Fine Mechanics and Optics, Chemicals, and others. Other responsible authorities include various Ministers of the Foreign Chamber of Trade.

Trading Possibilities and Difficulties

The German Democratic Republic (G.D.R.) has a population of approximately 17,000,000 and covers an area of 41,600 square miles. The standard of living is considerably below

that of the Western countries, economy being concerned primarily with the production of engineering and allied equipment for export. It therefore became evident that there is a potential market for all types of engineering production equipment. The report of the Birmingham Exchange and Engineering Centre states the view that " this area offers tremendous trading possibilities not only to British engineering manufacturers, but to almost all other industries, particularly the domestic consumer field."

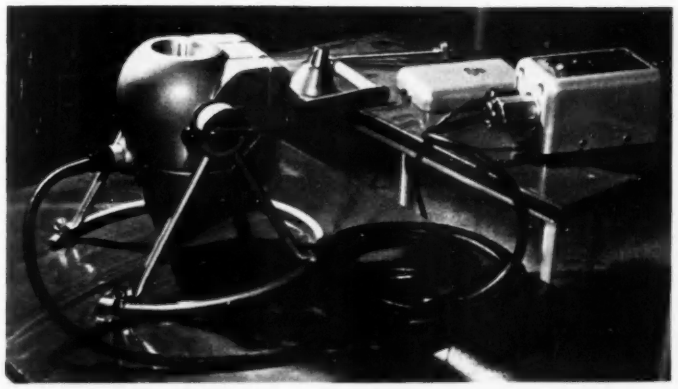


Fig. 26 Radioactive-isotope manipulating unit for non-destructive workshop testing made by Transformatoren und Röntgenwerk, Dresden.

There is, however, one considerable difficulty: the G.D.R. has very little sterling, and while she is extremely anxious to trade with Britain, this could only be done on a barter or clearing basis in the early stages. For example, it would be necessary to balance the export of, say, electronic computers to the G.D.R., by the import to Britain of possibly cameras and optical equipment. Such methods of trading are of course not unusual, and many British export-import organisations have successfully carried on business in this way with other countries. It is, however, necessary to have export and import licences from the Board of Trade, and because of the many political problems, not the least being that the British Government does not officially recognise the existence of an independent East German State, such licences are very difficult to obtain. In some instances, licences have been granted and a few British companies have successfully traded with the G.D.R. But, generally speaking, this problem of the lack of an official agreement makes it almost impossible to trade with Eastern Germany at the present time.

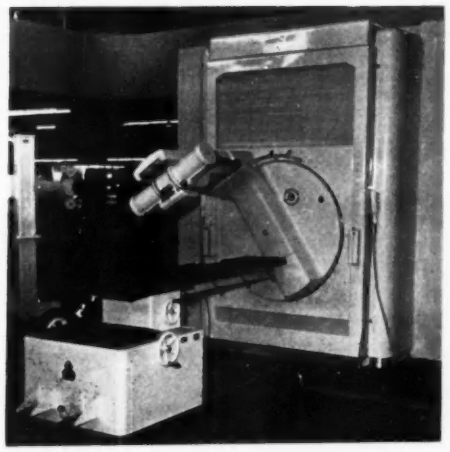


Fig. 27 Apparatus for deep radiation therapy made by Transformatoren und Röntgenwerk.

Fig. 28 The electric locomotive EL3 (BoBo) made by VEB Elektrotechnische Werke Hans Baimler weighs 75 tons and is for industrial use.

G.D.R. Trade with the West

These difficulties do not exist for some other Western countries, and many are now taking advantage of the market to be found in Eastern Germany. Foreign trade of the G.D.R. has in fact increased by 312 per cent. in the last year. Inter-German trade between East and West although not as high as the East would like, was in 1956, 43 per cent. higher than in 1955. If Britain is eventually able to trade, Western Germany will offer serious competition as she is already taking most active steps to establish herself in this market. Other countries like Norway, Sweden, Denmark, Belgium, Holland, France, India, Syria and Egypt are also actively trading with the East either by official or unofficial agreements. For example, G.D.R. trade with Syria in 1956 increased to almost three times the previous volume, with India to more than double, and with Egypt to over one and a half times the previous figure. As a matter of interest, the agreement with India is now on the basis of Indian currency and not on the pound sterling as hitherto. At present, relations are maintained with 22 countries on the basis of bi-lateral trade and payment agreements. Of these, nine are at Government level, five are agreements between banks and eight between chambers of foreign trade.

Demand for British Goods

During a discussion between the representative of the Engineering Centre and the President of the East German Foreign Chamber of Trade it was stated that even an unofficial agreement with Great Britain would enable trading to begin. It was suggested that this could possibly be arranged between banks or suitable associations. Some of the East German banks are, in fact, classed as private companies to assist trading with Western firms who are not anxious to enter into agreements with State-controlled organisations. Such an agreement would of course have to have the support of industrial circles in Great Britain and have influence on official circles and would obviously have to have Government approval. During this discussion it was learnt that the Soviet Union had just granted a subsidy to Eastern Germany of £1,000,000 sterling. It was however pointed out that this currency would be used with many of the other countries who deal in sterling and who trade at the moment with the G.D.R. Discussions with several other leading officials of the East German Chamber of Foreign Trade, showed that there is a strong desire to trade with Britain and to use British engineering products if only the problem of a trading agreement could be overcome. The President of the Chamber stated that East Germany hoped eventually to set up a market research office in London as had the Soviet Union, Rumania and Poland.

Sectional Trade Organisations

The following are reports of conversations with the directors of the separate East German trading organisations.

Machine Tools.—The director of the W.M.W. Machine Tool Export-Import Organisation, said that the machine-tool production of East Germany was the fifth largest in Europe and was leading in the Communist group. Owing to shortage of skilled labour his industry had in recent years concentrated on automatic machines and mechanical handling of machined parts between operations. Nevertheless the good quality of British machines was well-known in the German market and they were particularly anxious to import special machine tools including gear-cutting, chain-making and wire manipulating machinery, injection moulding machines and all types of bolt, nut and screw manufacturing machines.

Machine Export-Import.—For machinery other than machine tools the Machine Export-Import Organisation is responsible. East Germany is prepared to import all types of contractors' plant, machinery for the manufacture of ceramics, textile machinery, open-cast and underground mining machinery, special types of cranes, needles, and other wire products, and forgings, including those for heavy crank-shafts. The country's main source of fuel is soft brown coal or lignite, which is mined by the open-cast method. It is an industry that is being developed very quickly indeed and creating an extensive market for all types of earth-moving equipment, excavators, drag-links, and certain railway rolling stock. The general director of this group stated that G.D.R. stood first among all soft coal producing countries in the world, with a production of about 206 million tons per annum.

Fine Mechanics and Optics.—The precision instrument and optics industry is concerned more with export than with import. Carl Zeiss (Jena) cameras for instance, and optical instruments already have high reputations in all parts of the world, and are in great demand. Zeiss have, in fact, increased their pre-war production almost five-fold. (This is presumably in addition to the vast development of the West German firm of Carl Zeiss at Oberkochen.) The organisation is, however, anxious to buy small precision tools used in the production of such equipment. For example, milling, drilling and engraving machines, automatic screw machines, testing gauges and tools and also plating plant and lens-grinding machines. The director suggested that if trade were established between Great Britain and the G.D.R. items such as cameras could be re-exported by Britain to British Colonies and in return Colonial goods exported to East Germany. They are very short, for example, of such goods as cocoa, coffee, fruit, rubber and tobacco.

Polygraph Export-Import.—The branch of East German industry concerned with printing machinery and office equipment is known as

Polygraph Export-Import and is interested more with export than import. German printing machines, for example, are well known in this country and some trade already exists, principaliy with agents who are prepared to finance their own purchases. The volume of trade however is only a fraction of what it was before the war. As far as imports are concerned, this department would buy electronic computing and calculating machines of all types.

Transport Machine Export-Import.—The organisation responsible for transport equipment covers all types of vehicle from children's tricycles to merchant ships. The director stated that if trading agreements existed he would be prepared to place an initial order with Great Britain for 10,000 small cars. This group would probably buy more British goods than any of the others and was interested in large floating cranes, dredgers, cargo ships, Diesel engines, turbines, nautical instruments including radar, railway rolling stock and all kinds of agricultural machinery and tractors. As a matter of interest, this group are responsible for the production of East Germany's main car the "Wartburg", manufactured in the old D.K.W. factory. It is contemporary in styling, well-finished and has a 3-cylinder two-stroke engine and front-wheel drive. Its production, however, can never keep up with the home and export demand and only one person in every three hundred owns a car in East Germany at the moment.

Chemical Equipment Export-Import.—The section concerned with chemical plant has in the past been granted a sterling allocation and some trade with British companies has already taken place, particularly for cod-liver-oil plant and dairy equipment. It was stated, however, that this by no means satisfied their requirements and they would be prepared to buy complete equipment for the dairy industry, separators and other items, brewery plant, ships' refrigerating plant for whalers, air-cleaning plant, chemical pumps, rotary compressors, special chemical valves and electro-plating plant.

Three Other Satellites

Discussions were also arranged by the Engineering Centre with the leaders of trade delegations representing a number of other East European countries, and summaries follow of the most interesting.

Czechoslovakia

A bi-lateral trade agreement does exist between Great Britain and Czechoslovakia although it was stated that the volume of trade could be considerably increased. Underground mining machinery is required and the trading organisation Strojimport is already in contact with several British firms. Steel rolls, forged and cast, are also wanted but these are being bought principally from West Germany as British quotations were considered to be generally too high.

Other requirements stated are for paper-making machinery, rock drilling machines, special machine tools and machines for the ceramic and glass-making industries. All types of heavy contractors' plant is also required. The Czechoslovakian delegate stressed that one of the best ways of increasing his country's trade with Britain would be for British firms to send experts to Prague to learn of Czechoslovakian requirements and to organise film shows, lectures, and other contacts, and generally make efforts to sell their products. He stated that this would undoubtedly produce results as such methods were already being successfully adopted by West German manufacturers.

Poland

It is possible for trading to take place between Poland and Great Britain and already several manufacturers are taking advantage of this extensive and newly opened market. Poland is about to develop a chemical industry concerned with the conversion of coal to derivative products, and requires the wide range of plant necessary. Poland is also interested in open-cast mining machinery, excavators of very large capacity, grinding machines for roller and ball-bearings and machinery for sulphur mining. Gear-cutting machinery of all types is required but at present the United Kingdom has an embargo on the export of this type of machine tool.

Bulgaria

Like Eastern Germany trading with Bulgaria is extremely difficult owing to lack of a suitable agreement. Bulgaria also has very little sterling and, as an example, the purchase of one ship used up their available allocation last year. If trading were possible, however, they would buy textile machinery, marine Diesel engines, medical supplies and chemicals.

Soviet Union

Information on trading with the Soviet Union has been published by the Board of Trade in a circular. The Board of Trade state that the foreign trade of the U.S.S.R. is a state monopoly under the immediate general direction of the Ministry of Foreign Trade. This monopoly is claimed to serve a double purpose: firstly, to protect the internal economy of the Soviet Union against economic instability in the outside world, and secondly, to fulfil the import and export tasks allotted it by the planners of the internal economy. The Ministry of Foreign Trade, and the Soviet trade delegations which represent it abroad, are in no way concerned with trade promotion in the commonly accepted sense of the term, but only in placing the previously planned volume and range of exports in the best market (not necessarily the most economically profitable market) and ensuring the previously planned volume and range of imports in accordance with the requirements of the internal economy.

Trade Delegation in U.K.

Actual import and export business is conducted through state trading organisations, which have the status of juridical persons, and are responsible for arranging prices, deliveries, terms of payment, and other details. Each is responsible for a specified range of commodities and has a representative on the Soviet Trade Delegation in the United Kingdom. The address of the Soviet Trade Delegation in the United Kingdom is 32 Highgate West-hill, London, N.6. Initial approaches by United

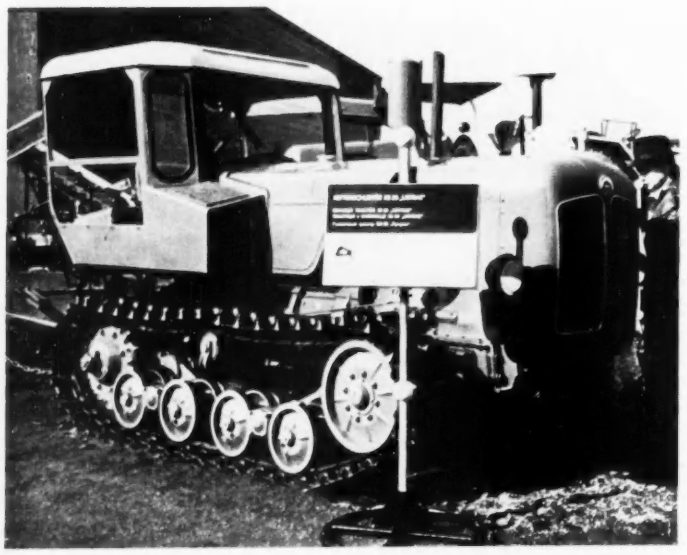


Fig. 29 Crawler tractor KS30 "Urtrak" made by VEB Brandenburger Traktorenwerk. It is powered by a four-cylinder Diesel engine with a whirl-chamber action capable of developing 63 horse-power.

Fig. 30 The three cylinder two-stroke engine of the "Wartburg-Sport" (Automobilwerk Eisenach) gives it a top speed of 140 km. per hour (87 m.p.h.).

Fig. 31 Two-seater P70 coupé built by Automobilwerk Zwickau with occasional seat and coachwork formed from "Duruplast."

Kingdom firms may be made either directly to the appropriate trading organisation in Moscow, or through the Soviet Trade Delegation in London. There are no agents, either official or unofficial, of foreign firms in the Soviet Union, nor is it possible to appoint one.

Import and Export Licences

Except in most cases where goods may be imported into this country on World Open or Non-dollar Open General Licence or under special licensing arrangements (such as open individual licensing) which include Eastern European countries, imports into the United Kingdom from the U.S.S.R. require specific import licences. It should also be remembered that export licences are required for those goods covered by the Export of Goods (Control) Order. Detailed information on this subject will be supplied on request by the Board of Trade (Export Licensing Branch), Atlantic House, Holborn Viaduct, London, E.C.1. Preliminary enquiries regarding trade should not be addressed to the Embassy, but to the Commercial Relations and Exports Department, Board of Trade, Horse Guards-avenue, London, S.W.1.

Straws in the Wind

The prospects for trade, its potential volume and character may to some extent be gathered from the following tables. The first lists orders said to have been placed during the fair by various countries with the German Democratic Republic, and the second enumerates import requirements expressly named by the G.D.R.

TABLE I *Orders said to have been placed with East Germany*

Argentina	.. Printing machines worth 50,000 dols. and machine tools worth 200,000 dols.
Austria	.. Drilling and milling machines worth 182,000 dols. Printing machinery worth 520,000 dols.
Belgium	.. Sewing machines.
Burma	.. Electric meters worth £15,000 also sweet making machinery.
Czechoslovakia	Printing machinery, materials testing apparatus, measuring instruments, textile machinery, tobacco machines, rotary printing presses and moulding machines.
Denmark	.. Large quantities of sewing machines.
Egypt	.. Stationary Diesel engines, low-voltage switching apparatus.
Finland	.. Ships' Diesel engines and steel pipes.
France	.. Sewing machines and office machinery.
West Germany	Telephone exchanges.
Holland	.. Drilling machines, hand grinding machines, sewing machines.
Iceland	.. Woodworking machinery.
India ..	.. Electro-technical apparatus and cine-film worth 100,000 dols.
Italy ..	.. Chemicals and clinical thermometers worth 50,000 dols.
Japan	.. Typewriters and accounting machines worth 100,000 dols.
Norway	.. Sewing machines, hunting guns and Perlon stockings.
Poland	.. Cameras, heating equipment and artificial rubber.
Sudan	.. Sewing machines.
Switzerland	.. Reflex cameras worth 38,000 dols.
Turkey	.. Film and photographic paper worth 196,000 dols.
Yugoslavia	.. Glass to the extent of 17,000 dols.

TABLE II *Intended Purchases by the German Democratic Republic*

Mining Products: Titaniferous ores, pyrites, mica, crude phosphates, feldspar, graphite.
Metallurgy: Iron ore, refined steel, various rolling-mill products, pipes, sheet metals, profile tool steel, rolled products of non-ferrous metals.
Mechanical Engineering: Mining equipment, precision tools for the metal-working industry, cutting and punching tools, machines for the foodstuffs industry, steel bottles, iron and metal ware, chains, wire ropes, screws and bolts, cutter blanks.
Precision Engineering, Electro-Technical and Optical Products: Cables and wires, X-ray apparatus and accessories, medico-mechanical products, controlling and measuring apparatus, watches and accessories, special electro-technical and precision engineering, optical equipment.
Chemical Industry: Organic and inorganic products such as phosphate fertilisers, borax, dyes and pigments, acetyl cellulose, photo-gelatine, pharmaceutical products, oils, laboratory and analytical chemicals, caoutchaouc, various rubber articles, fatty acids, linseed oil, celluloid.
Building Materials: Fireclay and magnesite products, crude slate, crystal glass for mirrors.
Wood: Converted leaf and pine timber, leaf and pine round timber, fibrous wood, exotic wood, cork, veneering and joiner boards, masonite boards.
Textile and Leather Products: Wool, woollen fabrics, cotton, rayon, flax, hemp yarn, jute and hard fibre, skins and hides, animal hairs, rags.
Cellulose and Paper Products: Cellulose, cellophane, paper for technical purposes, special paper, paste and cardboard.
Agricultural Produce, Foodstuffs and Stimulants: Butter, cheese, breeding animals, meat, fish, fish preserves, fish meal, fruit, tropical fruit, vegetables, fruit juices, pulp, hops, dried fruit, oil seeds, pulse, vegetable fat, rice, coffee, cocoa beans, tea, cigar and cigarette tobacco, wines, spices, forest and fodder plant seeds, guts, osier withes.

AERIAL BOBSLED EJECTOR SEAT

In the March 15 issue of ENGINEERING, we gave a brief description of the ejection seat, for baling out at 1,500 m.p.h., under development by the Lockheed Aircraft Corporation, Burbank, California, as part of the Industry Crew Escape Systems Committee (ICESC) programme. Now comes news of another ejection system for upwards escape, co-operatively developed under ICESC, the work being co-ordinated by the Convair Division of General Dynamic's Corporation, San Diego.

Described as an " aerial bobsled " ejection seat for supersonic jet aircraft, it projects the pilot feet-first and on his back into the supersonic airstream; it is aerodynamically shaped and equipped with stabilising fins. In the supine position the new seat strikingly resembles a bobsled. Wind tunnel and slingshot tests with dynamically scaled miniature models have indicated that the seat will have stable flight characteristics.

The ICESC bobsled, or " B," seat is one of two main configurations under development and study. The other, designated the " A " seat by ICESC, is an upward ejection version of the forward-facing skip flow generator seat already mentioned. Both seat configurations are to be developed through the sled test phase.

Rotation of the seat and pilot 90 deg. into the supine position before separation of the seat from the cockpit is one of the distinguishing features of the " B " seat. The pilot is located and secured by actuation of the D ring on the seat, which automatically reels the pilot's boots firmly into stirrups. The stirrups and the seat pan then curve upward, positioning the pilot's knees firmly against his chest at the same time that his arms, shoulders and head are supported in place against the seat to prevent flailing. This part of the ejection sequence takes about $\frac{1}{4}$ second.

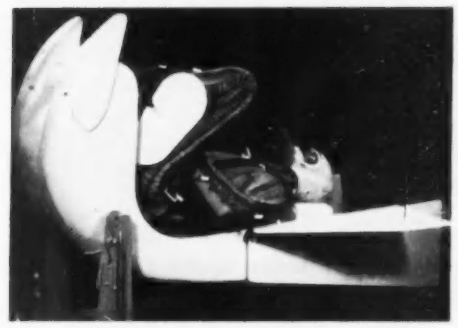
An explosive charge starts the seat up the rail and on its way out of the cockpit. For the first 19 in. of its upward path the seat remains in its normal upright attitude. Then a scissors carriage on which the seat is mounted begins to rotate man and seat backward through a 90-deg. arc. By the time the seat has cleared the cockpit area and the pilot, feet first, is lying on his back in the seat ready for separation from the aircraft, less than a second has passed.

A small rocket engine in the seat then is ignited and the seat is separated automatically from the aircraft. Man and seat are carried forward and lifted above any aircraft structures both by the rocket's propulsive force and by the aerodynamic lift designed into the external contour of the seat itself. Stabilising fins on the sides of the seat slide upward and fold out automatically as the seat rises out of the cockpit. The fins help to prevent tumbling of the seat in the airstream.

Models of both " A " and " B " seats have been tested extensively in wind tunnels and both have demonstrated stability characteristics superior to present-day ejection seats. To evaluate properly the trajectories and flight characteristics of both seats, a complex high-speed multiple-exposure still camera was developed for the programme. Variable from 10 to 2,000 images per second, the camera can record the precise trajectory of a miniature seat model being tested in a wind tunnel on one sheet of film. It is remotely controlled from an electronic console.

Northrop Aircraft, Inc., developed for ICESC a windblast rocket sled on which the " B " seat will be tested at ARDC's Experimental Track Branch, Edwards Air Force Base. Eight windblast runs, during which the " A " seat will be positioned at various attitudes and at varying speeds, are scheduled at the Mojave Desert track. Later platform and cockpit ejection tests will be conducted at the SMART Track Facility at Hurricane Mesa.

The final configurations of both seats has not been determined, but preliminary evaluation of



A mock-up of a new aerodynamically contoured ejection seat. The seat is rotated into the supine position and ejected into the airstream by a small rocket motor.

the " B " seat by designers who advocate this approach to pilot ejection at supersonic speeds shows these characteristics of streamlined contouring: (1) The " knee-chest " position protects the pilot's viscera from windblast damage. (2) By rotation of the contoured seat parallel with the aircraft before ejecting the seat-man mass into the supersonic airstream, the " B " seat presents less drag force and hence requires less rocket propulsion to clear plane structures. Hence the pilot is subjected to lower deceleration forces, inasmuch as aerodynamic forces are balanced with rocket thrust in such a way that separation of the seat from the aircraft can be accomplished with the least shock to the seat occupant. (3) Human-factors engineers estimate a man can withstand approximately 35*g* perpendicularly to his spine but only 10*g* if deceleration forces cause blood to rush to his head. Thus, in a supine position, an ejecting pilot is physically in a better position to endure rapid vertical acceleration as the ejection seat is projected into the windstream. (4) Because of its aerodynamic lift properties, the " B " seat will glide to a safe altitude for chute deployment without tumbling or pitching. Chute deployment on both seats is controlled automatically by an aneroid, an actuating device that resembles an altimeter in principle. On the other hand, the " A " seat has the advantages of lighter weight, more simple operation, and greater compatibility with existing cockpit configurations.

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PUSH-BUTTON CONTROL

In keeping with the needs of the times, much care is now being directed to maintaining Britain's standing in the automation field. To focus current ideas, the Institution of Production Engineers, 10 Chesterfield-street, London, W.1, is holding a conference on " Automatic Production: Change and Control " at the Hotel Majestic, Harrogate, from June 30 to July 3. The programme includes two case studies, some 16 papers, film displays and an exhibition.

Marketing

SERVICE IN A CARAVAN

The caravan continues to provide outlets for the enterprising. The latest to break new ground in this field, Technivision Limited, have set up a mobile studio in a " Rapier " caravan where they carry out the production of technical literature, including illustrating and the writing of copy. The company consider that the mobile studio will save time by enabling their clients to consult more easily with the studio team. " The studio is spacious enough to house a Technivision team, including illustrators, a visualiser and a technical writer, who can all work under normal conditions."

Such a development may bring about far reaching changes in the provision of services for industry. For example, an extension of a company's drawing office could be provided in a matter of minutes by calling in a mobile unit; product testing, design co-ordination between user and supplier, operational training and a host of other needs can be filled in this way. It is a most interesting development, likely to have an important and, so far as one can judge, beneficial, impact on supplier-user relationships. The Army—shades of Montgomery and others—proved the point in the second World War.

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Indian Summer

The announcement that India was to start three new projects with the help of credits offered by Russia shows quite clearly—Communist threat or not—that India's greatest need is capital. This has been underlined recently by a tightening up of restrictions on the import of some engineering products, including Diesel engines. There is a considerable shortage of foreign currency. For the next few years at least the Indian Government must direct industry's purchases of foreign equipment and materials to countries willing and able to offer long-term credit.

The Russian offer for a credit of 500 million roubles is likely to be used mainly for the development of the Korba coalfield, involving the supply of mining machinery and equipment; the erection of a thermal power station in South India, to operate on lignite; the manufacture of methanol and the production of optical glass. The set-backs experienced by some British engineering firms in recent weeks—one Diesel engine builder has been forced on short-time largely because India has reduced her import programme to conserve sterling—suggests that the British government need to review the whole position affecting the prospects of British exporters.

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The British in India

Some indication of the growth of the Indian and Pakistan markets for the more complex capital goods required by basic industry was given by Birlec Limited recently. Since 1946 Birlec have sold more than £1 million of electric furnaces to the Indian sub-continent. Twenty-two arc-melting furnaces have been supplied and orders booked for the area exceed £½ million. Although most of the furnaces sold are of the arc-melting type, Birlec have supplied a 5 ton mains-frequency coreless induction holding furnace to the Tata Engineering and Locomotive Works.

A recent visit by Birlec's managing director, Mr. George P. Tinker, has been followed by the decision to entrust the handling of the company's interests in India and Pakistan to A.E.I. (India) Limited, who have headquarters in Calcutta and branches throughout the area. The need to have local companies as a prerequisite of any expansion has been emphasised by several engineering firms in recent months. In most cases the ultimate objective is the setting up of local manufacture—at least in part—of products formerly imported.

The formation of the Consolidated Pneumatic Tool Company (India) Private Limited by the British parent company is a good recent example. The new company will be complementary to the Consolidated Pneumatic branches in Bombay and other large towns " as the entire sales and service organisation will continue without change and will handle C.P. products of the British, Indian and United States factories." Pneumatic tools, rock drills and demolition tools, pumps and air compressors are all scheduled to be made locally. Such developments are in line with what has happened in the past in markets bent on a policy of rapid industrialisation. There is an urgent need for British engineering firms, for whom India is an important market, to review the needs of the country's industry and to assess the main directions in which it is developing.

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Symphony in Oil

The growth of the Middle East's importance as a market for capital goods and as a source of oil is strikingly illustrated in the *Survey of Activities* of the Shell and Royal Dutch Group of Companies. In 1938 the area produced 120 million barrels of crude oil; in 1947 this figure had risen to 315 million barrels and last year to 1,215 million. And, irrespective of political crises, there is every sign that this rate of expansion is going to be maintained. In Iran, output of crude oil was some 65 per cent. higher than in 1955, " in spite of reduced off-take during the last two months of the year following the closure of the Suez Canal." The Suez crisis illustrated better than any publicity could have done " the growing and vital importance of oil as a source of energy in western Europe."

It is too early perhaps to assess the impact of the Eisenhower doctrine upon the prospects of British engineering firms in the area. There can be little doubt that there will be some impact, since large-scale credit facilities for the development of agriculture and industry are expected to follow in the next few months, particularly in Iran.

The talk given recently by the chief buyer of Shell Petroleum, Mr. E. N. Hague, to the Scottish branch of the Council of British Manufacturers of Petroleum Equipment, contained much useful information on the likely demand for plant and machinery for oil exploration, output and transportation in the area. The Suez crisis is doubtless affecting the attitude of all major oil producers in the area. If developments should follow the expected pattern there will be a vast increase in the demand for steel tube for pipelines and all ancillary equipment, including pumps, compressors and prime movers. And, side by side, there should be a vast growth in the demand for machinery and equipment needed to raise the standard of living of the peasantry.

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A.B.C. of Selling Oil Plant

The oil industry prides itself on being progressive, ruthless, enlightened and, above all, in a hurry. Its needs are scheduled and orders are placed accordingly. To fail to deliver on time, and therefore to upset those schedules, is a crime not easily forgiven. Oil companies never tire of repeating that what they want from their suppliers is unquestioning compliance with their wishes and that they are prepared to pay to get this. The industry considers it can succeed in keeping up its expansion rate only if its suppliers are an enthusiastic bunch of people who will stop at nothing to keep a promise or get over an unexpected difficulty, or who will turn themselves upside down to meet a revised schedule for the delivery of plant or a change in the specification.

The point of view of the man who buys over 40 per cent. of the purchases in the United Kingdom by the oil companies is given forcefully and in much detail by Mr. E. N. Hague, the chief buyer of Shell Petroleum, in the talk mentioned in the note above. In 1956, Shell bought £44 million worth of equipment and materials in the United Kingdom, for shipment to over 100 countries. Yet, said Mr. Hague, " our buys would have been very much greater if delivery periods were shorter." They have over 3,000 suppliers, buy goods to the value of more than £5,000 a year from 470 of them, over £100,000 from 69 companies and over £1 million each from their six leading suppliers.

Mr. Hague could not say enough on the question of delivery times. But he also had much to say on the time taken to send out quotations, on the need to increase standardisation to ensure " interchangeability of parts from different suppliers " and on the importance of setting up service organisations in the countries concerned. Mr. Hague's talk was both practical and constructive—a most useful statement of a buyer's point of view.

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Tapping Canadian Oil Markets

In order to ascertain the market for British-made equipment for oil refineries in Canada, the C.B.M.P.E. (the Council of British Manufacturers of Petroleum Equipment) are sending a " technical, economic and goodwill " mission to Canada. Under the leadership of Mr. J. M. Storey, managing director of Dewrance and Company, Limited, the team will also include 11 representatives from a variety of firms—manufacturers of Diesel engines, instruments, tools, fittings and electrical equipment—who supply to the oil industry. The team meets in Montreal on May 25, and then moves from east to west stopping at Ottawa, Toronto, Sarnia, Winnipeg, Regina, Calgary, Edmonton and Vancouver, whence the team disperses on June 19.

At the end of the trip the team expects to produce a report, to be published, that they hope will benefit everyone, large and small, contemplating breaking into the Canadian market. Particularly will they have to determine the cost and other difficulties involved in matching the supply service now available from the United States: what the buyer wants—*not* the nearest that'll do—at short notice.

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Export Know-How for Sale

The entry of a manufacturing group in the field of export selling on other firms' behalf is something of a novelty in engineering. The Dohm Group Limited, who have 14 factories in this country making a wide range of products including fertilisers, plastics and metal manufactures, have set up a new organisation to provide a " universal export service." The scheme, which was conceived by their Danish-born chairman, Mr. S. A. Dohm, is operated by a team of specialists picked for their knowledge of international trading problems. The organisation will produce an international buyers' index, which will marry the needs of manufacturers in all leading markets.

The Dohm venture is an interesting attempt to combine the functions of the agent and the marketing consultant. It is presumably based on the Group's existing export sales organisation which has been making rapid progress over the past two years. The company's statement suggests that their service will be more advisory than executive and that it will in the main be limited to the provision of market information and to effecting introductions between buyer and seller.

Fig. 1 View of the Dounreay site, showing the fast reactor sphere, and to the right, chemical plant and the materials testing reactor (DMTR).

FRAMEWORK FOR STUDYING NUCLEAR FUELS

BUILDING THE DOUNREAY ATOMIC ENERGY ESTABLISHMENT

At Dounreay in the north of Scotland the Industrial Group of the United Kingdom Atomic Energy Authority has set up its first major research establishment. Unlike the Group's other plants, which are concerned broadly with the manufacture of products for sale, Dounreay Works will be mainly occupied in research and development —principally on the use, processing and fabrication of nuclear fuels. Among its facilities will be a fast breeder reactor, a materials testing reactor, chemical plant, and laboratories, most of which can be seen in various stages of completion in Fig. 1. Last week in an article beginning on page 610, we summarised the work of the establishment and gave a general description of the fast reactor. The present article, the first part of which appears to-day, examines the Dounreay project in greater detail, paying special attention to the construction and engineering work involved and the contributions made by various contractors. Certain items may be described separately in later articles, or in Atomic Review, where, this week, a description of the Dounreay Materials Testing Reactor is published, together with an account of the testing programme to be adopted.

1—Fast Breeder Reactor

Probably the most notable feature of the Dounreay site will be the fast-breeder reactor. Contained in a steel sphere 135 ft. in diameter, it will not only evolve heat for conversion into electrical energy, but also, by means of a nuclear conversion process, create more fuel than it consumes. A discussion of this process was published last week. Fig. 2, which shows the general layout of the reactor and its heat-exchange and power-producing plant, will assist in locating the various items mentioned in the following descriptions.

Reactor Vessel

The vessel for the Dounreay fast reactor is said to be the most complicated stainless-steel vessel ever produced in Britain, and probably in the world, and has taken 18 months to build. Made by John Thompson Limited, of Wolverhampton, it will contain the core of enriched fuel, the breeding blanket, the control-rod operating mechanisms, recording instruments, and the liquid-metal coolant, which surrounds the fuel and is circulated through the stainless-steel inner circuits of the primary heat exchangers.

A cut-away view of the vessel, which should not be confused with the much larger containing sphere, was reproduced on page 610, last week. While the core of the reactor is only some 2 ft. high by 2 ft. in diameter, the vessel containing the core and ancillary parts is 20 ft. in height by 14 ft. overall diameter and weighs 45 tons complete with top shields. It is shown under construction in Fig. 3.

The complete vessel must be absolutely leakproof, and every welded joint has been examined by gamma or X-radiography over its complete length. Tolerances called for in fabrication of the vessel were quite outside normal practice, requiring maintenance of such limits as 0·1 per cent. circularity, 0·03 per cent. alignment and almost perfect concentricity where several diameters were involved. On the diameter pf 14 ft., the fabrication was to within $\frac{1}{32}$ in. Such accuracy is particularly notable since there is a diametral shrinkage of $\frac{1}{4}$ in. due to welding. Apertures for control-rod mechanisms in the vessel were machined to 3 thousandths of an inch and lining-up of the tubes carrying these mechanisms had to be within $\frac{1}{32}$ in. in a length of 15 ft.

The complexity of the container may be judged from the following brief description. The container consists of a double-walled cylindrical outer vessel, with domed bottom and flat top, with a smaller inner cylindrical skirt reaching to about two-thirds of the depth of the outer vessel. This inner skirt, which can be seen in Fig. 3 surrounded by the lower ends of the tubes for the control mechanisms and instruments, will contain the core, bianket fuel and control rods. Between the periphery of the skirt and that of the outer vessel are a series of tubes and smaller pipes running from the top of the vessel to various levels below the base of the skirt. These tubes and pipes carry the operating mechanisms and connections for the control rods and instruments which will enter the core area from the bottom of the skirt. At the tops of the pipes, instrument boxes are welded in position and pipes carry connections from these out through the wall of the vessel. Similarly, pipes from the control-rod mechanism tubes carry connections from these through the upper wall of the vessel.

The double walls of the outer vessel are of $\frac{1}{4}$ in. and $\frac{1}{2}$ in. plate with a $\frac{1}{4}$ in. gap between, forming a jacket around the vessel, which will be gas-filled for reasons associated with the leak-detection system. At two levels around the outer vessel there are stubs to which the ingoing and outcoming liquid-metal pipework will be welded. The inlet is at the upper level. Within the vessel the flow divides. A proportion passes

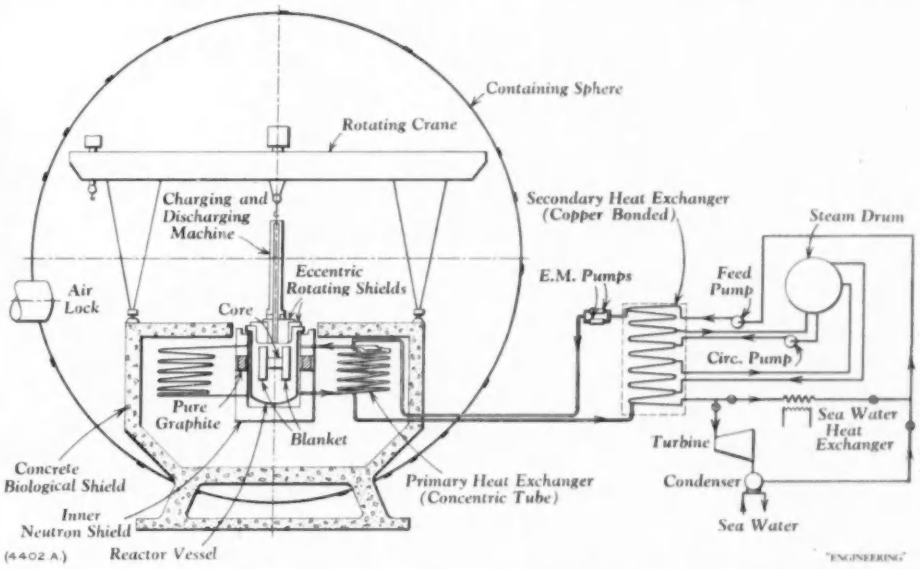


Fig. 2 Layout of the Dounreay fast breeder reactor. Heat will be carried from the reactor core by a liquid metal and transferred by way of a heat exchanger to a secondary (non-radioactive) liquid-metal circuit outside the reactor vault. Steam, generated in a second heat exchanger, will pass to a turbo-generator set, giving an electrical output of approximately 15 MW.

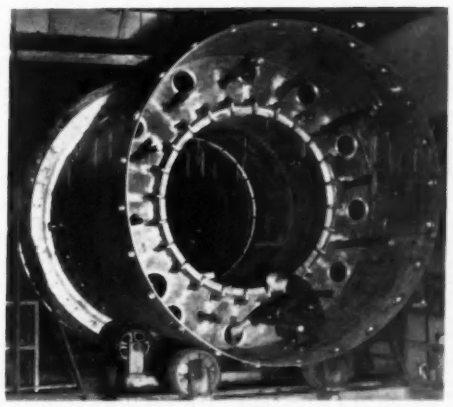


Fig. 3 Stainless-steel reactor vessel before fitting of domed bottom and outer jacket. The ends of tubes for control-rod mechanisms and instruments surround an inner skirt which contains the reactor core and blanket, together with liquid coolant.

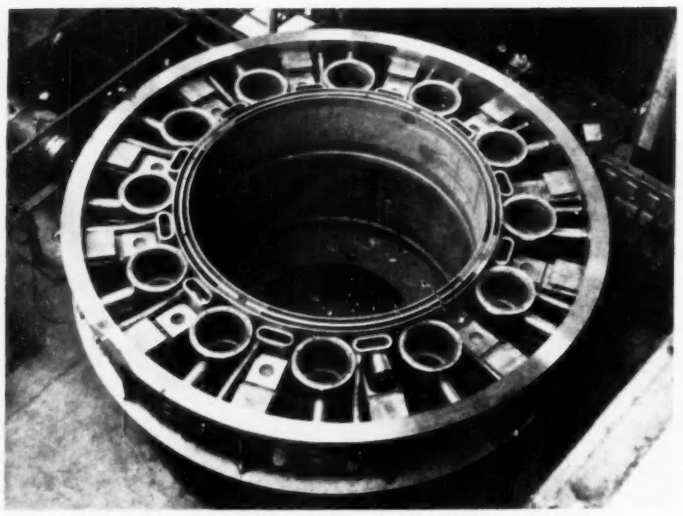


Fig. 4 Part of reactor vessel. One of the rollers on which the top shields rotate is shown in the foreground. The three-walled cylinder (centre) forms a liquid seal in which a double skirt fitted to the top shield rotates.

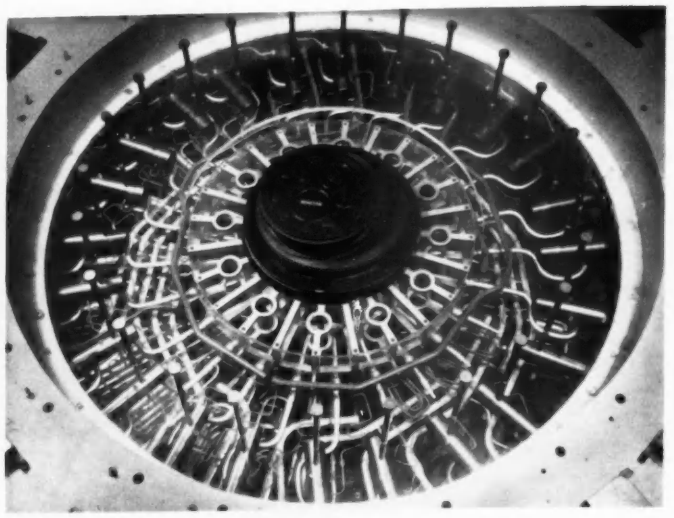


Fig. 5 Model of Dounreay reactor, showing reactor vessel surrounded by primary liquid-metal circuits. The eccentric arrangement of the two rotating top shields permits scanning of all fuel channels separately.

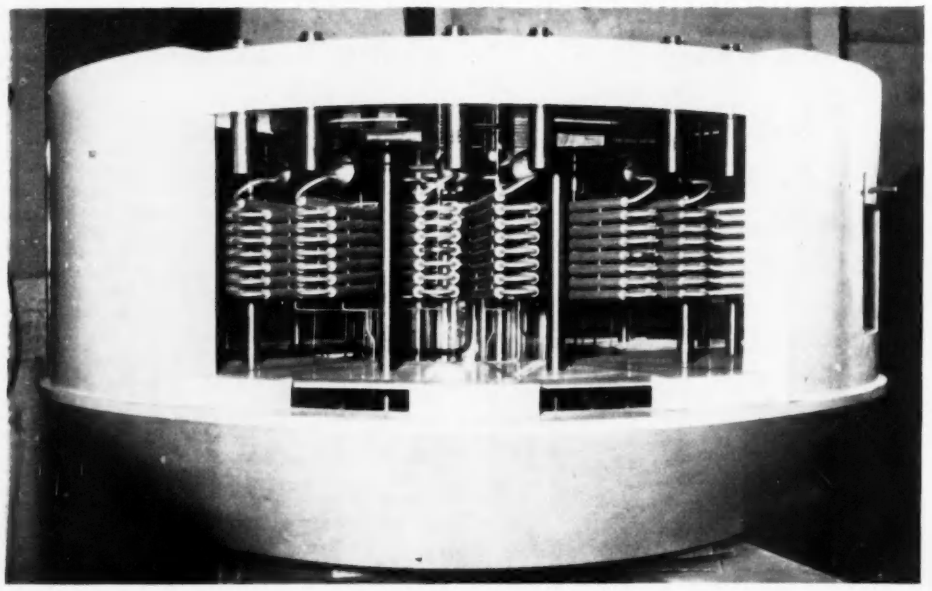


Fig. 6 The arrangement of primary heat exchangers, liquid-metal pumps (horizontal cylinders) and cold traps (vertical cylinders) may be seen from this side view of the fast-reactor model.

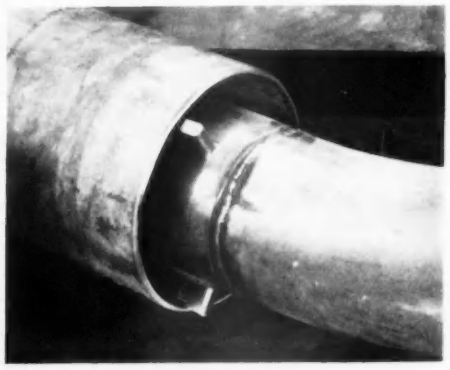


Fig. 7 Stainless-steel pipework for liquid-metal heat-exchange circuits. Spiders butt-welded in place act as spacers between the inner or primary circuit connected to the reactor, and the outer circuit to the secondary heat exchangers.

Fig. 8 Transitional section of heat-exchanger pipework. Extruded branch nipples form junctions to leak-detection circuits and secondary liquid-metal circuits.

through the blanket area and does not mix with the main body of the coolant, being led to four of the outlet stubs at the lower level.

The top of the vessel is a complex arrangement of rotating shields or plugs, graphite-filled and disposed eccentrically one within another so that a limited opening in the inner shield can, by movement of the rotating elements, scan the whole area of the reactor core and breeder blanket.

Rollers mounted on pads on the vessel carry the outer shield which in turn has roller pads supporting the inner shield mounted eccentrically within it. One of the rollers on which the outer shield rotates is shown in position in the foreground of Fig. 4. The three-walled cylindrical section, which can be seen at the centre of the vessel, forms a liquid seal in which a double skirt on the top or inner shield rotates. The eccentricity of the shields may be gathered from Fig. 5, which shows a model of the reactor. During operation of the reactor the rotating shields are raised off their rollers by a jacking mechanism so that the heavy rings which form their periphery make a firm seal with machined surfaces on the member on which they are mounted. In addition, liquid seals are maintained between each rotating part during charge and discharge operations, as already explained.

Primary Circuits and Heat Exchangers

The use of liquid-metal circuits and liquid-metal to liquid-metal heat exchangers for the fast breeder reactor has necessitated special fabrication techniques in stainless steel in order to meet all the conditions imposed; this work has also been undertaken by John Thompson Limited.

The primary or inner heat exchangers surrounding the reactor vessel and contained within the concrete biological shield, or vault, are in 24 banks, the complexity of which may be gathered from Fig. 5, while Fig. 6, which is a side view of the same model, shows the arrangement of the banks. The exchangers consist of inner and outer tubing spaced concentrically by spiders, as can be seen in Fig. 7. The inner tubing forms the primary circuit connected to the vessel.

The outer tubing provides the secondary circuit, which passes out of the vault to the secondary heat exchangers. The primary circuits are each provided with an independent electromagnetic pump and cold-trap purifier and are paired to serve 12 secondary circuits. Sections of the primary circuit not enclosed by the secondary circuit, that is, between the heat exchangers and the reactor vessel, are enclosed by tubes which form a gas-filled jacket monitored by the leak-detection apparatus. Fig. 8 shows a typical transitional piece of pipework; extruded branch nipples are for junction to leak-detection circuits and secondary liquid-metal circuits.

Since the primary circuit contains radioactive sodium during operation, and the secondary heat exchangers contain sodium and water circuits, it is essential to ensure the highest possible leak tightness. This has required the development of techniques to enable the complete system to be built as butt-welded units with argon-arc slag-free seal runs. Valves have

been completely eliminated from the design. Quality control of the highest order was maintained throughout manufacture, commencing at the steelmaker's works and including intrascope inspection after hot drawing. Following cold-drawing to size, the tubes are hydraulically tested and finally inspected under water while air-filled to a pressure of 100 lb. per sq. in. Heat treatment is performed to a temperature of 1,050 deg. F. (566 deg. C.).

Secondary Heat-Exchange and Boiler Plant

Design and manufacture of the boiler plant by John Thompson in collaboration with the U.K.A.E.A. involved the production of a secondary heat-exchange system between liquid-metal and water that would serve as a slave to the reactor, controlling the reactor temperature. Whereas the temperature rise through the reactor depends on load and liquid-metal flow, the operating temperature level is controlled solely by conditions in the secondary heat exchange and steam plant. With this in view, the plant is designed to give utmost reliability by the use of twelve separate small boiler units, each serving one of the secondary liquid-metal circuits (and, therefore, two of the primary heat exchangers), and by the duplication of most of the auxiliary equipment by providing stand-by plant.

These boiler units will control the temperature of the reactor by rejecting heat from the system either to a sea-water dump heat-exchanger or partially to this dump exchanger and partially to a turbine. They are arranged to operate by rejecting heat either from water or from steam. By use of a by-pass in the dump-exchange system the amount of heat dumped, and therefore the operating temperature, can be variably controlled. Superheaters and economisers are incorporated and can be isolated or brought in to suit the requirements of water dumping or steam dumping.

The 12 heat-exchanger units each comprise a steam water dump approximately 4 ft. 6 in. diameter by 4 ft. 3 in. long, with water feed boxes and steam separator, operating in conjunction with 7 banks of three heat-exchange units. Each of these 21 units is made up of 13 elements including preheaters, evaporator and superheater elements, so that in each boiler there are 21 parallel water-steam circuits. The elements each consist of one water tube surrounded by four liquid-metal tubes, the five tubes being mounted in close packed copper laminations which provide heat conductivity while also providing a means of directing any possible leakage from liquid-metal tubes away from the water tubes, and conversely. The arrangement of the five-tube sets with their copper matrix is evident from Fig. 9. Tubes for both water and liquid-metal are of stainless steel. The elements are coupled together by inlet and outlet headers for preheaters, evaporators and superheaters. The secondary heat exchanger units are shown in process of erection in Fig. 10. The boiler units are completely instrumented, with instrument panels by the John Thompson Instrument Company.

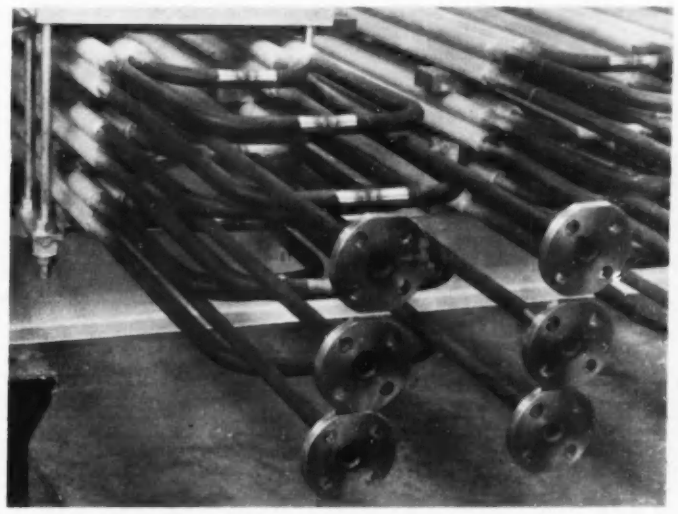


Fig. 9 Close-packed copper laminations serve as a matrix for the central water tube and the four surrounding liquid-metal tubes in the secondary heat exchangers.

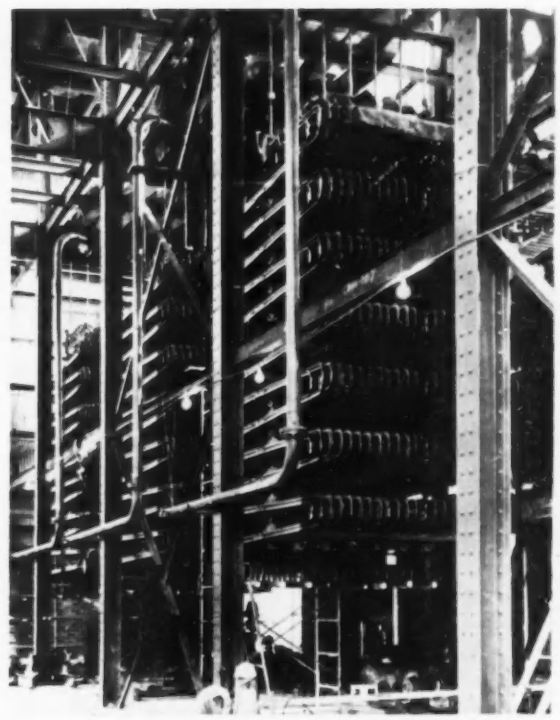


Fig. 10 Secondary heat-exchanger units (liquid-metal to water) being installed outside the reactor vault.

Water Treatment and Site Work

Feed water for the boiler-heat-exchanger plant is treated by two mixed-bed de-ionisation units of 1,000 gal. per hour output, supplied by John Thompson Kennicott Limited, complete with valves, piping and instrumentation. The John Thompson group are also concerned with site and erection work, and in addition have set up a special school for training argon-arc welders in the quality of work required for the liquid-metal circuits.

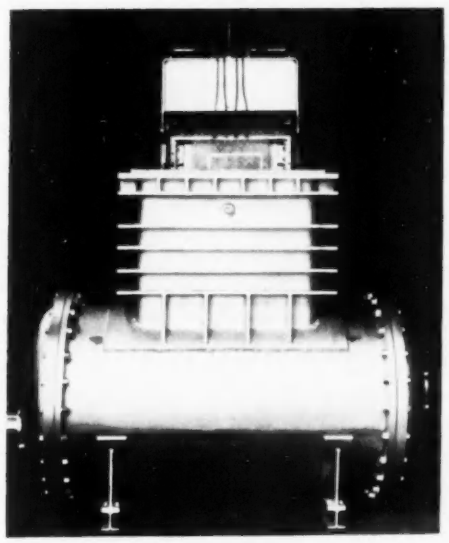


Fig. 11 The stators of the flat linear induction pumps (electromagnetic) used for pumping liquid-metal coolant may be withdrawn through access columns without disturbing the hydraulic circuit. A stator is shown being replaced.

Liquid-Metal Pumps

Important items in the liquid-metal circuits are the electromagnetic pumps. Built at the Stafford works of the English Electric Company, Limited, they are of flat linear induction type and operate on the principle of the three-phase induction motor. Pumping force is applied solely by electromagnetic means and the pumps, one of which is shown in Fig. 11, have neither moving parts nor glands. Their position within the vault can be gathered from Figs. 2 and 6, where they may be seen as cylinders immediately below the upper shield. (An article prepared by Mr. D. A. Watt of the Atomic Energy Research Establishment, Harwell, describing the action of electromagnetic pumps and comparing various different designs, appeared in ENGINEERING on April 27, 1956, vol. 181, page 264.)

The flat pump tube forms part of the liquid-metal circuit, and to secure a leak-tight system, is welded to the ends of the circuit. On each side of the flat tube is clamped a slotted stator carrying a three-phase electrical winding, which has class-H insulation of mica-glass-silicone. The windings produce a magnetic field in the fluid travelling along the tube, so inducing eddy currents across the liquid metal in the channel, which serve to generate the pumping force.

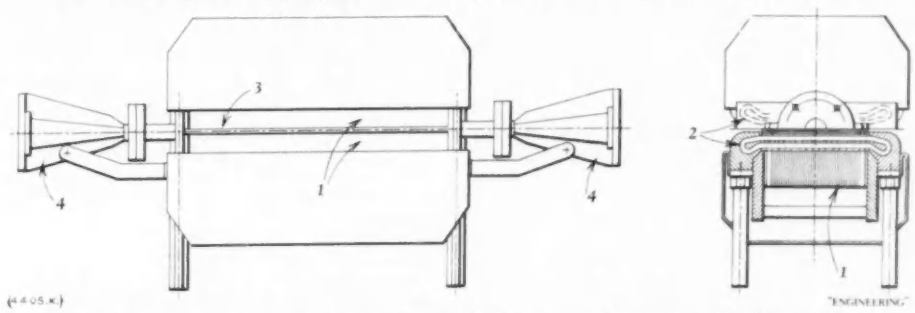


Fig. 12 Layout of a typical flat linear induction pump for pumping liquid metals.

1. Cores (laminated structures of electrical sheet steel)
2. Windings (arranged to reduce the undesirable field pulsation often associated with linear devices; class H insulation permits winding temperatures up to 180 deg. C.)
3. Pump tube (tube is of rectangular section; copper side bars give low-resistance paths for the current in the liquid metal and have the same function as the end rings connecting the rotor bars of a squirrel-cage induction motor)
4. Diffusers (transition between rectangular section of pump tube and circular section of external circuit)

The arrangement of a typical English Electric flat linear induction pump (F.L.I.P.) is illustrated in Fig. 12. The complete pump operates within a steel tank provided with a vertical access column. The stators can be lowered on guide rails down this column and clamped on to the pump tube by remote means; they can therefore be replaced without disturbing the hydraulic circuit. The guide rails are hinged to act in addition as pendulum links, which allow the pump to move sideways as the pipes to which it is connected expand with rising temperature. There are 24 electromagnetic pumps in the active primary circuits and a further 24 in the non-active secondary circuits. Fig. 11 shows one stator assembly (that is two stators with clamp gear) entering the access column of a secondary circuit tank. The primary circuit tanks are similar but include much longer access columns to accommodate a heavy radiation shielding plug. The tanks are filled with nitrogen and sealed.

In advance of the Dounreay project, two complete prototype pumps were designed and built by the Nelson Research Laboratories of the English Electric Company. These have been set up in a pumping rig at the Authority's Capenhurst Works and operated by the Research and Development Branch. The accompanying table shows data for an English Electric F.L.I.P. of approximately the size and performance of those installed at Dounreay.

Data for English Electric Flat Linear Induction Pump of Similar Size and Performance to those in the Liquid-Metal Coolant Circuits of the Dounreay Fast Reactor.

Pump size classification	..	10	(10)
Liquid pumped	..	70/30 sodium-potassium	(sodium)
Flow (gal. per min.)	..	400	(400)
(litres per sec.)	..	30	(30)
Pressure (lb. per sq. in.)	..	16	(28)
(kg. per sq. cm.)	..	1·1	(2·0)
Overall length including diffusers	(in.) ..	53·5	
	(cm.)	136	
Overall height	(in.)	20	
	(cm.)	51	
Overall width	(in.) ..	30	
	(cm.)	76	
Nominal bore of diffuser outlet	(in.) ..	4	
	(cm.)	10·2	
Weight	(lb.)	1,500	
	(kg.) ..	680	

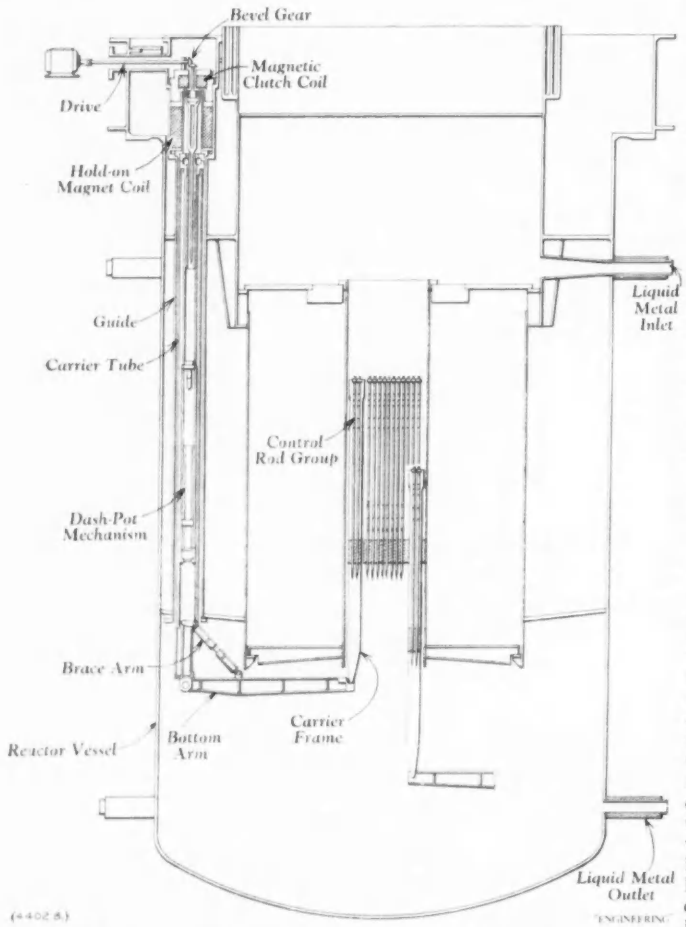


Fig. 13 Arrangement of control rods and control mechanism inside the fast reactor vessel. Control is not by the insertion of neutron-absorbing rods but by removal of certain fuel elements, which may be lowered from the core to reduce reactivity. Reserve control rods are also provided.

Tubing

As a sub-contractor to John Thompson Limited, the Talbot Stead Tube Company, Limited, Green-lane, Walsall, supplied for Dounreay 311,000 ft. (60 miles) of stainless-steel seamless tubing in sizes ranging from $\frac{1}{2}$ in. to $6\frac{1}{2}$ in. outside diameter, in various thicknesses. The bulk of this tubing was supplied in straight lengths to John Tompson for inclusion in the primary heat exchangers, the bonded exchangers, and for use inside and outside the sphere. A quantity of this tubing was provided as special tube turns of 90 deg. bends and in all a total of 1,700 of these were supplied. In the liquid-metal heat exchanger, intricately machined stainless-steel spiders were needed to be used as spacers to position the inner and outer tubes, and approximately 1,200 of these were used. Over one million stainless-steel Raschig Rings were also supplied. Various other items that were delivered by Talbot Stead to John Thompson Limited included the following: control-rod connection stubs, tube connection stubs, control-rod tube corner rings, equalising pipe stubs, indicator and heater tube end stubs, thermocouple tube end stubs, indicator tube rings, control-rod tube ends, control-rod tube branch stubs, control-rod tube locating rings, instrument-box branch stubs, thermocouple tube flanges, gas-vent connection stubs, thermocouple inner-tube stubs, liquid seal tube flanges, liquid seal tube stubs, and drain connection stubs.

Vault Insulation and Cooling

All internal surfaces of the reactor vault have been covered with metal-clad insulation panels made by Henry Hargreaves and Sons, Limited, Cook-street, Bury, Lancashire. The panels form part of the cooling system on all internal vault surfaces, protecting the concrete shielding and roof columns from the effects of the high operating temperature inside the vault. Each of the 1,200 panels was constructed from mild-steel sheets and plates packed with mineral wool with over 500 perforations to accommodate the labyrinth of pipes, plant and equipment housed in the vault. A drawing showing the disposition of cladding in the vault, together with other details, was published in ENGINEERING on April 19 (pages 509 and 510). The insulation was fitted, clamped and sealed in position on a system of mild-steel support channels and stools arranged so as to allow free and even air flow over all concrete and roof support column surfaces with a two-pass system serving the roof. The cooling air is introduced in a closed circuit at floor level in the vault and is forced over wall and roof surfaces before extraction at roof level for cooling and recirculation. An unusually high standard of accuracy was required, to meet which, sections of the installation were pre-assembled at the works.

Control and Instrumentation

Control of the fast reactor is achieved by movement of parts of the core, and therefore differs from the Windscale and Calder reactors, where control is effected by moving neutron-absorbing steel rods in or out of the pile. Twelve groups of fuel elements located at the corners of the core hexagon form the control rods which may be moved in or out of the core. These fuel elements are held in a metal frame resting on a support arm within the liquid metal, enabling the control rods to be raised into the core to increase its reactivity or dropped below the core to shut the reactor down. A magnetic clutch is incorporated in each control-rod drive to allow the drive to be transmitted through the reactor vessel without leakage of fission products. Each control rod and support within the reactor vessel is supported by an electromagnet, so that interruption of electrical supply to the electromagnets allows the rods to fall rapidly out of the core, thereby shutting down the reactor. The arrangement of the control mechanism may be seen in Fig. 13. It was made in consultation with the U.K.A.E.A. by various contractors, including Vickers-Armstrongs (Newcastle) Limited; the Fairey Aviation Company, Limited, Hayes, Middlesex; Sir W. G. Armstrong Whitworth Aircraft Limited, Coventry (control-rod carriers); and Turbine Gears Limited, Stockport, Cheshire (control-rod gear drive).

As all the twelve control rods are of identical design it is feasible that a common fault could develop in the mechanism which could prevent their satisfactory operation in an emergency. To provide a reserve control enabling the reactor to be shut down under these abnormal conditions, three rods containing neutron-absorbing boron may be dropped into the inner row of breeder elements surrounding the core. The design of these boron safety rods differs from that of the control rods, so that the possibility of their failure at the same time as that of the control rods is remote.

The positioning of the control and safety rods is controlled from a desk in the control room by means of a selector switch and push buttons. Operation of an emergency push button on the desk cuts the current to all the appropriate electromagnets and drops all the control rods and boron safety rods simultaneously. In addition to normal or emergency shut-downs controlled by the operator from the control desk, automatic shut down occurs in the following circumstances: (1) failure of pressure in the primary gas blanket; (2) high temperature in the centre of the core; (3) insufficient flow of liquid-metal coolant through the core and breeding blanket; (4) a high level of neutron flux; and (5) an abnormally rapid rate of increase in neutron flux. Electromagnetic flowmeters measure the flow of liquid-metal coolant in the primary and secondary circuits, and the nuclear behaviour of the reactor is recorded by means of ion chambers located in the graphite shield surrounding the reactor vessel.

All operations involving a change in reactivity are controlled from the desk in the control room. The instruments indicating or recording the behaviour of the reactor and its heat-extraction circuits are grouped on the outer instrument panels. The panels on the left of the control room contain audio-signals and annunciators which give warning of fault conditions and enable individual faults to be located.

Charge and Discharge Equipment

The fuel charging and discharging equipment has been built by Strachan and Henshaw, Limited, of Bristol. Its operation and the problems it was designed to solve were discussed on page 613 last week.

Other Items

Constructional work, including erection of the reactor containing sphere; and electrical equipment, including the power plant for the fast reactor, will be treated in a subsequent article. A list of contractors will also be published.

To be continued

ATOMIC REVIEW

Testing Materials

ALTHOUGH in many senses the advent of atomic energy has called merely for an extension of existing engineering practice, there is one field in which rapid advances have proved necessary. Metallurgy, and the study of materials generally, is in process of revolution. The new factor that has brought about that development is the tendency for materials to undergo significant changes under radiation. In a reactor, fuel, moderator, coolant, shielding and the materials used in construction are constantly subject to bombardment, and it is essential to know before designing a nuclear power station how these substances will behave in the conditions to which they will be exposed—conditions which include, in addition to radiation, high temperatures and pressures, and corrosive atmospheres. Tests, in which selected materials are exposed to bombardment, must be performed under controlled laboratory conditions and although accelerators and other particle and radiation sources may be used, there is only one convenient means of providing neutrons—a rare commodity—fission particles and other forms of radiation in the right combination—a reactor. The following article discusses a typical materials-testing programme and a materials testing reactor.

Fig. 1 The Dounreay high-flux materials testing reactor (DMTR) is designed to enable materials of construction, fuels, canning materials, and coolants to be irradiated in conditions similar to those in full-scale power reactors.

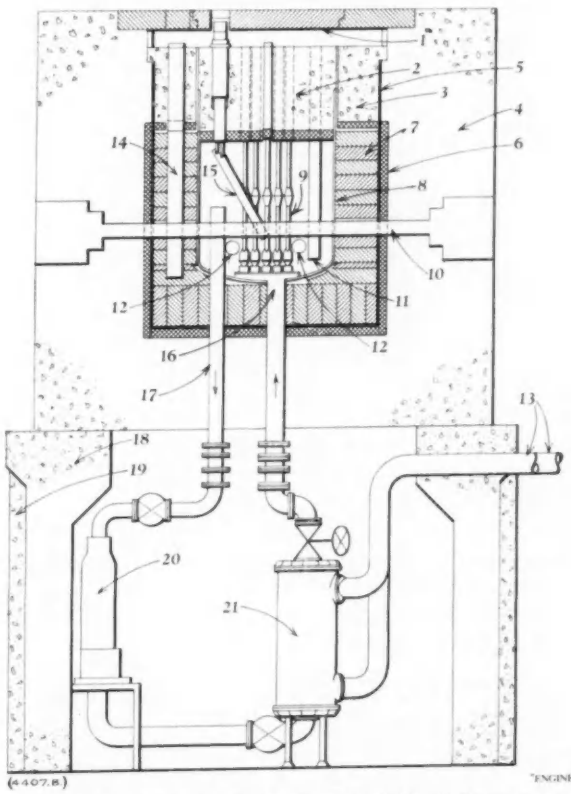
Irradiation Testing

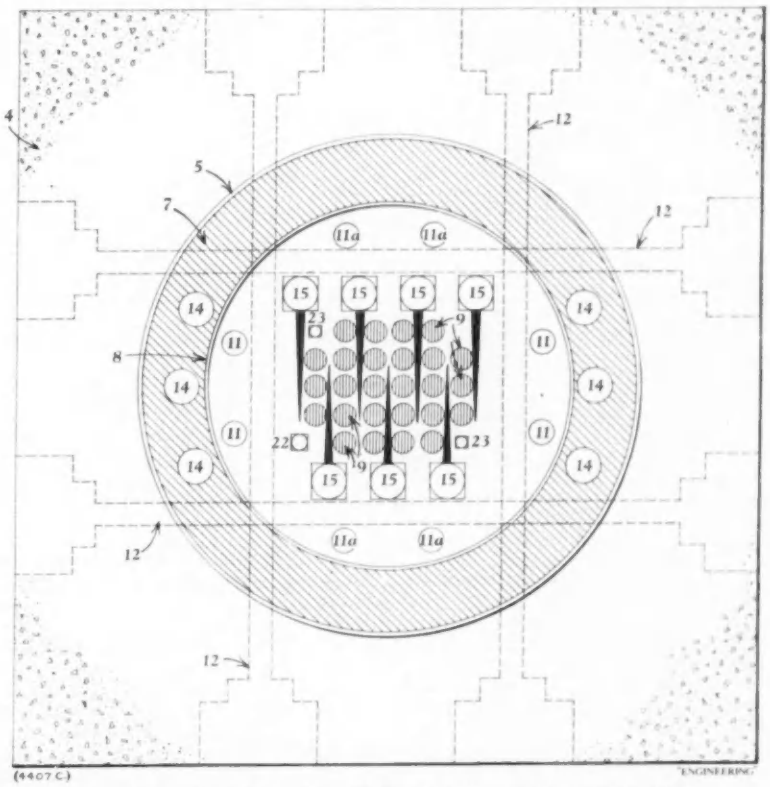
The efficiency and economy of nuclear reactors as power producing units depends finally upon the provision of materials possessed of the necessary physical and mechanical properties, corrosion resistance and dimensional stability at high temperatures and under irradiation. Under bombardment by fission product particles, neutrons, alpha particles, and beta and gamma radiations, materials may suffer considerable changes in their normal physical and chemical behaviour. Interactions with the electron shells of atoms may cause them to become highly ionised and reactive with otherwise inert materials. Corrosion by water and carbon dioxide, for example, tends to be accelerated under irradiation. Conversely, reactions normally occurring may be suppressed, and natural corrosion processes be inhibited in the presence of radiation. As a result of collisions with fission particles, atoms may be displaced from their normal positions on their crystal lattice, and the sub-microscopic processes leading to diffusion, conduction and deformation so distorted as to bring about large changes in the mechanical and physical properties of the material. In the case of uranium fuels, the high flux of fission particles at high energies allied to the complexity of the uranium crystal structure produces most striking effects, which can be observed visually in changes of shape and volume, and also by determination of mechanical and physical properties.

Specification of materials for reactors so far constructed has been based, inevitably, upon data gained during exhaustive tests conducted out-of-pile. Experience gained in the operation of these reactors, and experiements carried out in them has yielded valuable information on the effects of irradiation. Of necessity, however, these reactors were designed to work at moderate levels of temperature and neutron flux. With the provision of research reactors at Dounreay and Harwell, it now becomes possible to subject materials to specific conditions of temperature and neutron flux. Materials may receive in a comparatively short period an irradiation dosage equivalent to that received during their service life in a power reactor.

Dounreay Materials Testing Reactor

To speed research into problems associated with the design and construction of reactors planned in the development of the nuclear power programme, the Industrial Group of the United Kingdom Atomic Energy Authority is constructing a research reactor at Dounreay. A view of the reactor building, which is a steel cylinder 70 ft. high and 70 ft. in diameter, appears in Fig. 1, while Figs. 2 and 3 show the general arrangement of the reactor and its facilities. Known as the Dounreay Materials Testing Reactor (DMTR), it is designed to enable materials of construction, fuels and their canning materials, coolants and heat-transfer media to be irradiated in its neutron flux under specific design conditions which can be related to those in a full-scale power producing reactor. The method of testing materials is to incorporate them into test rigs or loops which in turn are inserted into DMTR and irradiated to the required degree. The test rigs are then removed





Figs. 2 and 3 Sectional elevation (left) of Dounreay materials testing reactor and sectional plan (right), showing experimental facilities.

1. Reactor top plate (mild steel)
2. Aluminium tank top shield (concrete in mild steel)
3. Annular top shield (concrete in mild steel)
4. Biological shield (concrete)
5. Reactor steel tank
6. Lead shield
7. Graphite reflector
8. Reactor aluminium tank
9. Fuel elements (26)
10. Horizontal experimental facilities (two 7 in. diameter; plus two ref. 12)
11. Vertical experimental facilities in heavy water (four 7 in. diameter)

11*a*. (four 4 in. diameter)

12. Horizontal experimental facilities (two 7 in diameter)
13. Water cooling inlets and outlets (3 of each)
14. Vertical experimental facilities in graphite (six 4 in. diameter)
15. Coarse control arms (7)
16. Heavy-water inlet (3)
17. Heavy-water outlet (4)
18. Heavy-water plant-room biological shield
19. Lead-shot concrete
20. Heavy-water circulating pumps (3)
21. Heavy to light water heat exchangers (3)
22. Fine control rod (1)
23. Shut-down rods (2)

and dismantled and the test materials are subjected to appropriate examination. Since DMTR has a high neutron flux, research work previously requiring a long period of irradiation due to lack of large neutron sources can be completed in a much shorter time.

DMTR is an enriched-uranium heavy-water moderated and cooled thermal reactor with a peak flux of 10^{14} thermal neutrons per sq. cm. per second at a total output of 10 MW. It is similar to DIDO inaugurated at Harwell last November but with the major difference that the experimental facilities are fewer, and designed for large engineering test rigs. The core of DMTR consists of 26 box-section fuel elements mounted vertically in a cylindrical aluminium tank containing heavy water. The tank is surrounded by a graphite reflector and the whole is enclosed in a steel tank, which itself is surrounded by a lead shield. Further shielding is provided by concrete walls which contain the reactor in a cube of 20 ft. side. The reactor is controlled by the introduction of neutron absorbing material in the form of 7 coarse control arms of the signal-arm type, which move between the fuel elements, and a single vertical fine control rod. In addition there are two shut-down rods. The reactor is mounted directly above the heavy-water plant room which houses pumps and heat exchangers to reject the heat from the heavy-water coolant to a light water circuit which in turn dissipates the heat to atmosphere in eight cooling towers situated outside the reactor.

The experimental facilities consist of four vertical 7 in. diameter and four vertical 4 in. diameter tubes in the heavy water and six vertical 4 in. diameter tubes in the graphite reflector. In addition there are four horizontal 7 in. diameter tubes which pass through the reactor close to the reactor core.

Details of DMTR

General.—The enriched uranium core, of overall dimensions 2 ft. high by 2½ ft. by 3 ft., is immersed in heavy water, acting as moderator, reflector and coolant, and is contained in a ½ in. thick aluminium tank of 6 ft. 7 in. internal diameter, 11 ft. high. It is surrounded by a thick graphite reflector which is itself contained in a steel tank, ¾ in. thick, 8 ft. 9 in. internal diameter and 12 ft. high; the tank has a ¼ in. thick boral lining and a 4 in. thick lead lining, acting as a gamma shield. A 5 ft. thick, 218 lb. per cub. ft. concrete biological shield encloses the tank. The top chield is 4 ft. 4 in. thick and of iron-shot concrete of 350 lb. per cub. ft. The depth of heavy water is 6 ft. and the surface is blanketed with helium. At 10^{14} neutrons per sq. cm. per sec. peak core flux the fission heat is 10 MW.

Core.—There are 26 fuel elements, arranged in a 6 in. by 6 in. lattice in a 5 by 6 array, with corners unoccupied. Each fuel element consists of 10 curved plates of aluminium-clad, uranium-aluminium alloy, 0·058 in. thick and 0·177 in. apart. The 10 plates form an element 2·88 in. by 2·53 in. by 25 in. long. The heavy-water coolant flows at 11·3 ft. per sec. past the fuel element at 11·5 lb. per sq. in. gauge inlet pressure, and 44 deg. C. inlet and 51 deg. outlet temperatures.

Control.—There are seven, signal-arm type controls, suspended at 1 ft. intervals along both 3 ft. sides of the core, at 19·6 in. from the centre vertical plane, and they operate downwards from a fully-out horizontal position over a 60 deg. arc, controlling up to 25 per cent. reactivity. Each arm contains a 2 mm. thick by 6½ in. by 42 in. strip of cadmium, enclosed in stainless steel and weighing 26 lb. Normal operating time for the full 60 deg. movement is 24 minutes but an emergency free-fall takes less than 1 second. In addition, there is a vertical fine control rod controlling ½ per cent. reactivity, placed at an unoccupied corner of the core. It consists of a 2 mm. thick cadmium sheet formed into a ⅝ in. outside diameter 24 in. long tube sandwiched between two stainless-steel tubes, the full 24 in. travel taking 15 seconds. Two safety rods are also provided, in diagonally opposite corners, formed of similar cadmium sheet into a 1⅜ in. outside diameter 30 in. long tube, sandwiched between two aluminium tubes.

Heavy Water Plant.—Three totally submersible 60 h.p. pumps (1 standby) deliver the required 4,800 gal. per min. of heavy water to the core and the 10 MW heat is removed in three stainless-steel heat exchangers to light water. The heavy water is continuously sampled at three points for purity, conductivity and pH value.

Light Water Plant.—Four pumps (1 standby) circulate the water from the heat exchangers to cooling towers, the make-up for evaporation requiring 81,000 gal. per day of treated water. The pressure is kept below that of the heavy-water, so that leaks will be out of the heavy-water circuits.

Reactor Hall.—The reactor hall is 70 ft. diameter and 70 ft. high. It is designed to contain radioactive dust in event of an accident; personal and vehicle access is provided through air-locks, therefore, and air pressure is maintained at slightly below atmospheric.

Thermal Neutron Fluxes.—The flux at the core centre is 10^{14} neutrons per sq. cm. per sec. maximum; in the heavy-water radial reflector it is 8×10^{13} falling to 10^{13}; in the graphite reflector it is 10^{13} to 10^{12} neutrons per sq. cm. per sec.

Irradiation Programme for DMTR

In drawing up the experimental programme for the Dounreay Materials Testing Reactor, highest priority is awarded to those projects which will provide the maximum information to the design teams of the Industrial Group of the U.K.A.E.A., and their collaborators in the commercial field. A minimum of six holes has been allocated to studies of the behaviour of different types of fuel under various conditions of temperature, stress, and burn-up rate. Information will be gained on the tendency of the fuel to grow or swell under irradiation, changes in thermal conductivity, hardness, mechanical strength and metallurgical structure, and the ability of various types of can to restrain the deformation of the specimen. At the completion of these tests it should be possible to state not only the best fuel composition or structure for a given set of conditions, but also, perhaps, the length of time for which it may safely be irradiated, and the most suitable material in which to contain it. A further hole will be used for tests on fuel elements for commercial reactors, together with their supporting structures.

Three large holes will be available for research into the effects of irradiation on the corrosion properties of coolants such as sodium, sodium-potassium, carbon dioxide and hydrogen. Smaller facilities will be set aside for specialised problems of irradiation chemistry and for the development of analysis techniques dependent upon the formation of radioactive isotopes.

The behaviour of graphite under irradiation is of such fundamental importance in thermal reactor design, that investigations on this topic alone will occupy one or two holes. The remaining facilities will be devoted to measurement of the mechanical and physical properties of structural materials such as alloys of the rarer metals, beryllium, zirconium, niobium, molybdenum and magnesium of interest as container materials, and also various types of steel used in pressure shells and support structures. Studies will include the post-irradiation examination of irradiated material, and measurement of properties such as tensile strength, creep resistance, thermal and electrical conductivity and thermal expansion of specimens during irradiation.

Other Materials Testing Reactors

Similar to DMTR are the materials testing reactors PLUTO and DIDO at Harwell, and HIFAR now nearing completion at Lucas Heights, Australia. America and Canada also have reactors designed for this purpose, A Soviet beryllium-moderated reactor for test purposes will be discussed in a subsequent Atomic Review.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

HOVE
"Relays and Automatic Control in Industry," by Dr. W. L. Stern. Brighton, Hove and Districts Branch. New Imperial Hotel, First-avenue, Hove. Wed., May 29, 7.30 p.m.

Building Centre

LONDON
Films on wood supplies, exhibited by the Timber Development Association. Wed., May 29, 12.45 p.m.
Film: "The Yorkshire Way with Water," exhibited by Yorkshire Copper Works Ltd. Wed., June 5, 12.45 p.m.

Chemical Engineering Group

LONDON
"Granulation," by W. C. Peck. Society of Chemical Industry, 14 Belgrave-square, S.W.1. Tues., June 11, 5.30 p.m.

Chemical Society

LONDON
"The Vapour Pressure of Anhydrous Copper Nitrate, and its Molecular Weight in the Vapour State," by C. C. Addison and B. J. Hathaway; and other papers. Thurs., June 6, 7.30 p.m.

Combustion Engineering Association

LONDON
"Coal: Some Forecasts," by R. J. Moffat. London Region. St. Ermin's Hotel, Caxton-street, Westminster, S.W.1. Wed., June 12, 10.30 a.m.
SHEFFIELD
"The Production of Fuel Oils, Their Delivery, Storage and Preparation for Burning," by T. Marsden, at 11 a.m.* "Fuel Oil Firing for Furnace Work," by T. Chippindale, at 2.15 p.m. Northern Region. Grand Hotel, Sheffield. Wed., May 29.

Engineers' Guild

EDINBURGH
Luncheon Meeting. Speaker: Emlyn Jones, chief road engineer, Scottish Home Department. Scottish Liberal Club, 109 Princes-street, Edinburgh. Mon., June 10, 12.30 for 12.45 p.m.

Incorporated Plant Engineers

LONDON
"The Training of Plant Engineers," by J. Wilson. London Branch. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., June 4, 7 p.m.*
BIRMINGHAM
Brains Trust Meeting to discuss general engineering problems. Birmingham Branch. Imperial Hotel, Temple-street, Birmingham. Fri., May 31, 7.30 p.m.
MANCHESTER
"Air Compressor Maintenance and Installation, and Ancillary Equipment," by W. McMillan. Manchester Branch. Engineers' Club, Albert-square, Manchester. Tues., June 4, 7.15 p.m.

Institution of Civil Engineers

LONDON
"Portishead 'B' Power Station, with Particular Reference to the Circulating Water Works," by H. D. Morgan and Louis Sancha. Works Construction Division. Tues., May 28, 5.30 p.m.*
"The Regimen of the Thames Estuary as Affected by Currents, Salinity and River Flow," by Sir Claude Inglis and F. H. Allen. Maritime and Waterways Division. Thurs., May 30, 5.30 p.m.*
Annual General Meeting. Tues., June 4, 5.30 p.m.*

Institution of Electrical Engineers

GLASGOW
Annual General Meeting. "The Allt-na-Lairige Prestressed-Concrete Dam," by J. A. Banks. Scottish Centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Wed., May 29, 7 p.m. (Tea at conclusion of the meeting.)

Institution of Mining and Metallurgy

LONDON
"Mechanisms of Collector Adsorption and Dynamic Attachment of Particles to Air Bubbles as Derived from Surface-Chemical Studies," by J. Leja; "Flotation of Soluble Salts," by J. Rogers; and "The Assessment of Flotation Results," by J. C. Nixon and D. N. Moir. Geological Society's apartments, Burlington House, Piccadilly, W.1. Thurs., June 20, 5 p.m.*

Institution of Naval Architects

LONDON
"Further Experiments on Sideways Launching—Series 2 and 3," by D. J. Doust and E. MacDonald. Thurs., June 6, 4.45 p.m.*

Royal Aeronautical Society

LONDON
"Flight Instruments," by F. W. Meredith. Section Lecture. Tues., May 28, 7 p.m.

Royal Institution

LONDON
"How Glue Sticks," by Dr. N. A. de Bruyne. Fri., May 31, 9 p.m.

Royal Meteorological Society

LONDON
Discussion on "Long Waves and Storm Surges." Wed., May 29, 2 p.m. to 7 p.m.

Royal Society

LONDON
Discussion on "The Initiation and Growth of Explosion in Solids," to be opened by Dr. F. P. Bowden. Thurs., May 30, 10 a.m.
"The Mechanical Behaviour of Single Crystals of Metals, in Particular, Copper," by Dr. E. N. da C. Andrade and D. A. Aboav; and "Dislocations and Stacking Faults in Stainless Steel," by M. J. Whelan, P. B. Hirsch, R. W. Horne and W. Bollmann. Thurs., June 13, 4.30 p.m.*

Royal Society of Health

LONDON
"The Effects of Radiation on the Individual," by Dr. F. G. Spear. Wed., June 12, 2.30 p.m.

Society of Instrument Technology

LONDON
Annual General Meeting. Address by Sir Harold Hartley, G.C.V.O., who has accepted the presidency of the Society. Manson House, Portland-place, W.1. Tues., May 28, 6 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Engineering Group, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Combustion Engineering Association, 6 Duke-street, St. James's London, S.W.1. (WHItehall 5536.)
Engineers' Guild, 78 Buckingham-gate, London, S.W.1. (ABBey 7315.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Mining and Metallurgy, 44 Portland-place, London, W.1. (LANgham 3802.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Royal Society of Health, 90 Buckingham Palace-road, London, S.W.1. (SLOane 5134.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)

In Parliament

ENGINEERING APPRENTICES ON NIGHT WORK

There was a discussion in the House of Commons last week on the incidence of night working among engineering apprentices and the effects of this upon their technical training. Mr. Frederick Lee (Labour) thought that night working for these young men should be discouraged.

He pointed out that several apprentices at recent national conferences of the Amalgamated Engineering Union had stated that their colleagues were losing their chances of technical education because they were up all night at work and then could not get to the technical courses they needed during the day. He asked Mr. Robert Carr, the Parliamentary Secretary to the Ministry of Labour and National Service, to consider what action could be taken to influence employers not to put apprentices in need of technical education on to night work.

Mr. Carr said that his Ministry had no information of that kind. He could obtain the numbers of boys between the ages of 16 and 18 years in the engineering industry who did some night work. He did know that the numbers were extremely small and he doubted whether the exact information would be sufficiently useful to justify a special inquiry. If what had been referred to was happening, he certainly agreed that it was undesirable and he would carefully examine any information brought to his notice. At the same time, there was machinery within the industry for looking after such matters and he felt that the use of that machinery was the proper means of finding safeguards in this connection.

THE EMPLOYERS' PART

Some information was given by Mr. Carr regarding the facilities for technical training provided by employers as part of further education procedures. He told Mr. Lee the available statistics did not distinguish between apprentices and other young people. In the industrial group comprising engineering, shipbuilding and the manufacture of electrical goods, the number of students released by employers for part-time education in technical colleges had risen from 122,000 to 150,000 during the past four years. Although precise figures were not available, steadily increasing numbers of young persons were being sent by their employers on sandwich courses in engineering subjects at technical colleges.

While expressing his gratitude to the Minister "for those very encouraging figures," Mr. Lee suggested that the general pattern throughout the engineering industry was not satisfactory. It was acknowledged that some employers were very good indeed in helping in every way they could to provide education facilities for their apprentices. Indeed, they were doing as much as they could inside their works to help in this way. All the same, there were some employers who were not so good. In his opinion, they were penalising the good ones.

Mr. Carr said he would certainly do everything he could to encourage employers to give proper facilities. He hoped that the *Report of the Committee on Training Facilities* would help.

GERMAN TRAINING SCHEMES

On this subject of making adequate provision for the training of young people in technical and other matters, Mr. W. R. Williams (Labour) suggested that Mr. Carr should ask his chief, Mr. Iain Macleod, the Minister of Labour, to give very careful study to some of the new schemes which were now being adopted by German firms. In his opinion, they were well worth studying and, possibly, of adopting in British industry. Mr. Carr said he felt sure that Mr. Macleod would be pleased to investigate the steps being taken in Germany to deal with problems of technical training. He, himself, was paying a visit to Germany at the end of the week. Later in the summer, he hoped to lead a deputation to Germany on the training of the younger workers in industry.

SPECIAL APTITUDE SCHEME

Later, Mr. Carr stated that the allowances made to lads under the Special Aptitude Scheme of the Ministry of Labour were determined after taking account of their regular earnings and other income, and of any necessary expenses incurred while living away from their homes. The object of the scheme was to enable a boy, for whom training facilities were not available in his home area, to be able to benefit from the facilities provided in a distant area, and not necessarily to make him better off. The scheme was intended to ensure that boys should not be penalised through the lack of facilities in their own districts and it was accomplishing that.

Mr. Lee pointed out that the present arrangements were unsatisfactory. Boys were being asked to work more overtime and to try to earn more. When they did so, the money was put against the allowances which they received from the Ministry. It was putting a penalty on attempting to be more useful. Mr. Carr promised that the matter should be investigated.

CLYDE ATOMIC POWER STATION

Reference was made by Mr. G. M. Thomson (Labour) to the lack of progress in connection with the construction of an atomic power station at Hunterston on the Clyde coast. He asked whether the new public inquiry into the siting of this station was really necessary. The technological race for atomic power between the various nations of the world was so intense that any unnecessary delay might be very damaging for Britain.

Mr. Niall Macpherson, Joint Under-Secretary for Scotland, said that applications were outstanding for the consent of the Secretary of State for Scotland, under the Electricity Supply Acts, to the erection by the South of Scotland Electricity Board of a generating station at Hunterston; for his consent, under the Town and Country Planning Acts, to the project; and for his confirmation of a compulsory purchase order for the site. The Secretary of State, Mr. John Maclay, was required by statute to consider a report before reaching decisions on these applications. The late Sir Randall Philip, Q.C., had been unable to make a report before his death and Mr. Maclay had accordingly appointed Mr. Harold Leslie, Q.C., to hold an inquiry. The importance of the inquiry, and the great public interest exhibited in the matter, were recognised, but these were not reasons for interference by the Secretary of State with the proper conduct of the inquiry.

DE-SALTING OF SEA WATER

The House was told by Mr. Harmar Nicholls, the Parliamentary Secretary to the Ministry of Works, that the Department of Scientific and Industrial Research provides the United Kingdom representatives on the international steering committee which co-ordinates the research in the Netherlands on the de-salting of brackish and sea water. The D.S.I.R. had made a contribution of approximately £4,700 in each of the last two years. The appropriate contribution for the current year was still under discussion. Mr. Nicholls, who was replying on behalf of Lord Home, the Lord President of the Council, assured Mr. Ray Mawby (Conservative) that, if the experiments were successful, this country would be able to share in all the commercial advantages which would naturally arise. The D.S.I.R. had fully participated in this research and would have a full share in all the benefits which might accrue.

TRAFFIC AT ROUNDABOUTS

Attention was drawn by Mr. E. Partridge (Conservative) to the need for careful investigations being undertaken into the flow of vehicles at traffic roundabouts. He asked the Parliamentary Secretary to the Ministry of Works what works had been done by the Road Research Laboratory of the D.S.I.R. in this connection and whether any conclusions had been reached concerning the maximum capacity of these roundabouts. He also inquired whether the Laboratory had advised on the proposed roundabout at Hyde Park Corner.

Mr. Nicholls stated that the Laboratory had been studying traffic flow and behaviour at roundabouts under both actual and experimental conditions. Its investigations were leading to a better understanding of the factors involved and, particularly, of the relation between maximum traffic flow and the shape and dimensions of roundabouts, but it was not yet possible to forecast accurately the capacity of any special design under actual conditions. He believed that the research results of the Laboratory into the situation at Hyde Park Corner had contributed very materially to the decision of the Minister of Transport in regard to the provision of a roundabout at that junction. Mr. Nicholls agreed with Mr. P. Noel-Baker (Labour) that the prevention of accidents should be a major consideration in the design of roundabouts. The Minister said he reiterated what was the Government's intention all along the line: prevention was better than cure.

International Geophysical Year

Apart from the United States and Russia, Mr. Nicholls said, whose efforts, both in financial and practical terms, were greater than those of Britain, the programme of this country for the International Geophysical Year compared favourably with those of other nations.

So far as Britain was concerned, he told Mr. Partridge, the Radio Research Station of the D.S.I.R. would be the European regional centre for radio observations dealing with the ionosphere and atmospheric noise. There would be research into the upper atmosphere by firing high-altitude rockets from the Woomera range. Support had been given to the Royal Society's expedition to establish a scientific base on the Antarctic mainland at Halley Bay. America and Russia were each proposing to launch a number of earth satellites. It would be seen that quite a number of balloons would be going up for some useful purpose.

Dust and the Clean Air Act

A letter sent by the Bedworth Urban District Council to the Minister of Housing and Local Government at the beginning of this month, in regard to the dust nuisance caused at a coal dump in the Bedworth area, was referred to by Mr. F. G. Bowles (Labour). When told by Mr. Henry Brooke that the letter had been received and a reply sent, Mr. Bowles asked whether the reply indicated that his "constituents' furniture, houses, lungs and food would cease to be covered and damaged by coal dust blown across from this coal dump." Mr. Brooke said that the Council was mistaken in thinking that section 22 of the Clean Air Act was applicable to the matter. The Council itself had certain powers under part III of the Public Health Act, 1936.

Meeting the Need for Water

Mr. G. R. Mitchison (Labour) asked the Minister of Housing and Local Government what advice he had received from the Central Advisory Water Committee, or from either of its sub-committees, on supplies and demands for water, and when it was expected that any report of the committee would be published. The committee had been set up to give advice on a matter of some urgency. How did the Minister, Mr. Mitchison asked, make up his mind about dealing with water shortages, failing these reports or any advice? Mr. Brooke replied that he had not received advice from the committee, as it was awaiting reports from its sub-committees. Considerable progress had been made, but the inquiries were far-reaching and it could not be forecast yet when the reports would be submitted. There was a great deal of information in the Ministry about the water situation, but it would be of value to have the further advice that this committee would be able to furnish.

THE HUMAN ELEMENT

Pensions and the Professional Man

The Socialists have got in first with their plan for pensions for all, and given it the inevitable political flavour which must creep into all schemes of this kind. It has provided a basis for a reasonable standard of debate. The two most vital problems which face any national scheme are keeping the pension fund solvent and getting existing schemes, especially those run by companies, to fit into it.

It is not easy to run a pension scheme on the scale which this one would require without offering hostages to inflation. Contributions from both employers and employees would in fact be quite a substantial tax on prices and wages, with the consequence that both would tend to rise in consequence. Since the wish would be to keep the purchasing power of pensions about constant, there would tend to be a vicious circle established with pensions chasing prices and wages which in turn would chase pensions. A high standard of Government honesty would be required under the Labour scheme (and probably under a Conservative alternative) to preserve the solvency of the fund, and there are few safeguards in this first scheme to suggest that they would be forthcoming.

One vital point for professional men (whose votes are few) will bear watching in all this. Under a State scheme the contributions of the self-employed are likely to be heavy, and professional engineers can look forward to further erosion of the individual's right to do his own saving, and make personal economic decisions, if the compulsory principle is written into any scheme which is adopted.

Wages in Lieu of Notice

A case was brought recently before the Industrial Disputes Tribunal concerning a company in the engineering industry. The dispute was raised by the Transport and General Workers' Union on behalf of one of its members who claimed that he had been dismissed without proper notice. The issue raised was whether the employers should observe the recognised terms and conditions of employment in the engineering industry, and, in particular, those relating to payment of wages in lieu of notice.

It would appear from the report of the case that the union member concerned had threatened to use violence on another employee on a site. The company considered the position and decided that the man in question should be dismissed with two hours notice and he was paid off with five hours pay on that day. The company claimed that he had been dismissed for misconduct. The employee actually tendered his notice before he was dismissed. The union claimed that the man had been wrongfully dismissed and that the company should pay him the balance of a week's wages in lieu of notice. The tribunal found for the union. It therefore stands that, in the above circumstances, firms in the engineering industry are bound by the agreement between the employers and the Confederation of Engineering and Shipbuilding Unions of April 3, 1946, to pay on dismissal a full working-week's wages in lieu of notice.

A Touch of the Humanities

Lord Hailsham, Minister of Education, is driving hard along the new road he has mapped out for the technically educated of to-morrow. In a circular to local authorities he warns that the humanities must not be forgotten. Technical students must develop alongside their normal studies " a broad outlook and a sense of spiritual and human values." The circular suggests a number of ways in which a liberal element can be "injected" into a conventional technical course.

Lord Hailsham stressed the opportunity to give scientific subjects themselves much more liberal treatment than had been usual in the past. Students should learn something of the history of their particular science or technology, and the depth of its social and economic impact on human society. Many branches of science, he argued, offered excellent opportunities for deductive reasoning and more use should be made of them.

The circular calls for the development of corporate life in technical colleges, and for activities outside the curriculum. Much of this will only be possible when residential facilities become available, and Lord Hailsham can be expected to push and prod local authorities in that direction. He calls for an increased use of college libraries; for the adoption of less formal methods of teaching, such as seminars and discussion groups; for a careful fostering of tutorial relationships between teaching staffs and students similar to that found in universities; and for the establishment of close contact with institutions abroad. Examining bodies are urged to give a lead on the addition of non-technical subjects to part-time courses. Industry is also asked to play its part—by underlining the importance of the humanities through its recruitment policies.

Cybernetics Under Control

Following a congress of cybernetics in 1956 the Association Internationale de Cybernétique was founded recently with its headquarters at Namur in Belgium. It owes its inspiration mainly to those who are interested in international collaboration in this subject, in this country, in France and, naturally, in Belgium. It has been felt for some time that it would be worth the effort to establish such an international association to study the general principles of communication and control in machines and men.

A good deal of work in cybernetics has been on the control of mechanisms and how the principles so discovered are applicable to the control of the human body. The subject had something of a popular send-off several years ago with such publications as Norbert Wiener's book in the United States. At about that time a certain " left-wing " flavour became attached to the subject in a philosophical sense. This may be due to the fact that if certain principles can be set out as governing the control of the human mechanism, control begins to take a fascinating and possibly sinister meaning. It can become a tool in the hands of those who are only too willing to see all things in terms of historical necessity. One of the functions of an international association might well be to put the whole subject in its proper context.

Seed Corn of Industry

The teaching staff of technical colleges were recently referred to by Lord Hailsham as the " seed corn of industry." The report of a special committee on the supply and training of teachers for technical colleges, published last week, concludes that industry must do a great deal of sowing if it is to get the scientists and technologists it is likely to need. Speaking on the report, Dr. Willis Jackson who was chairman of the committee, emphasised that the demands of the schools and universities must be met largely from industry or Government departments. " For some time to come," Dr. Jackson said, " industry must be willing to accept—and encourage and assist—the transfer to the work of full-time teaching of experienced staff members that it can ill afford to lose."

Lord Hailsham, who spoke before Dr. Jackson, argued that the promotion of technical education should not be left entirely to the State. Addressing himself to his industrialist audience (the conference was held under the auspices of the Federation of British Industries) he said, " If you leave it to us to administer, it will be administered badly because technical education depends on industry." Dr. Jackson described as the " kernel of the report " the chapter which contains new provisions to make teaching attractive, including a proposal that local authorities should be empowered to grant increments for expenditure to enable teachers' salaries to be kept up to the levels of those paid by industry. Time spent in teaching should not be excessive, and more time should be allowed for research and remunerative consultant work. If all the recommendations of the committee are adopted teaching in technical colleges will become a more pleasant occupation and there should be no lack of recruits.

Craftsmen on the Offensive

A requirement of successful warfare is to maintain the initiative. In these days the craftsman is at war with changing techniques—not in the sense that he can hold them back—which is Luddism—but in the sense that he should be ever on the alert to mould them and his own skills to help maintain the craft tradition. In a recent article in the monthly report of the United Patternmakers' Association, Mr. Ellis Smith, M.P., having spoken of the dangers of complacency while pattern-makers watch their work going to other people, refers to a range of new machines in the following terms: " Our members should recommend the use of these machines . . . If the management consider they have not the orders for a machine then suggest a group of firms associate together."

There is always the danger that initiative from the side of labour in these matters will help someone tumble upon a technique which will kill a craft, but the risk by and large is worth taking. If craftsmen will take a constructive interest in technical development there is more likelihood that they will be able to adjust themselves to new machines and processes. There is a great need for the craft tradition to save itself by its own exertions. No other party is likely to make a full effort on its behalf.

No Place Like Home

The decision announced recently by the British Legion to establish branches in factories draws attention once more to the pull which " the works " has these days as a social centre. Sociologists have for long pointed out that an elementary exercise in arithmetic shows that men, if not women, spend most of their waking lives at work and must therefore seek some social fulfilment there. The list of types of organisation which rotates round the factory is now formidable: it ranges from darts clubs to amateur dramatics, from religious and political groups to machinery clubs.

This could go too far. It is probably only a question of time now before the profound discovery is made that although men may wish to find social fulfilment in the factory group, they also crave rest from working surroundings as well as from the cries of teething babies upstairs. Since the family represents the more basic urge and is consequently the more important, social theorists may begin to recognise the greater importance of home life. The fact is that there is a good deal of fashion in this kind of thing and it only needs a simple idea to be tricked out in new and complicated garb to attract a large audience. In the end we may have to admit that these matters are governed by fashion rather than by scientific laws. Should that be so, it will at least have the advantage that men will be regarded as individuals and not units in a herd.